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28 November 1958

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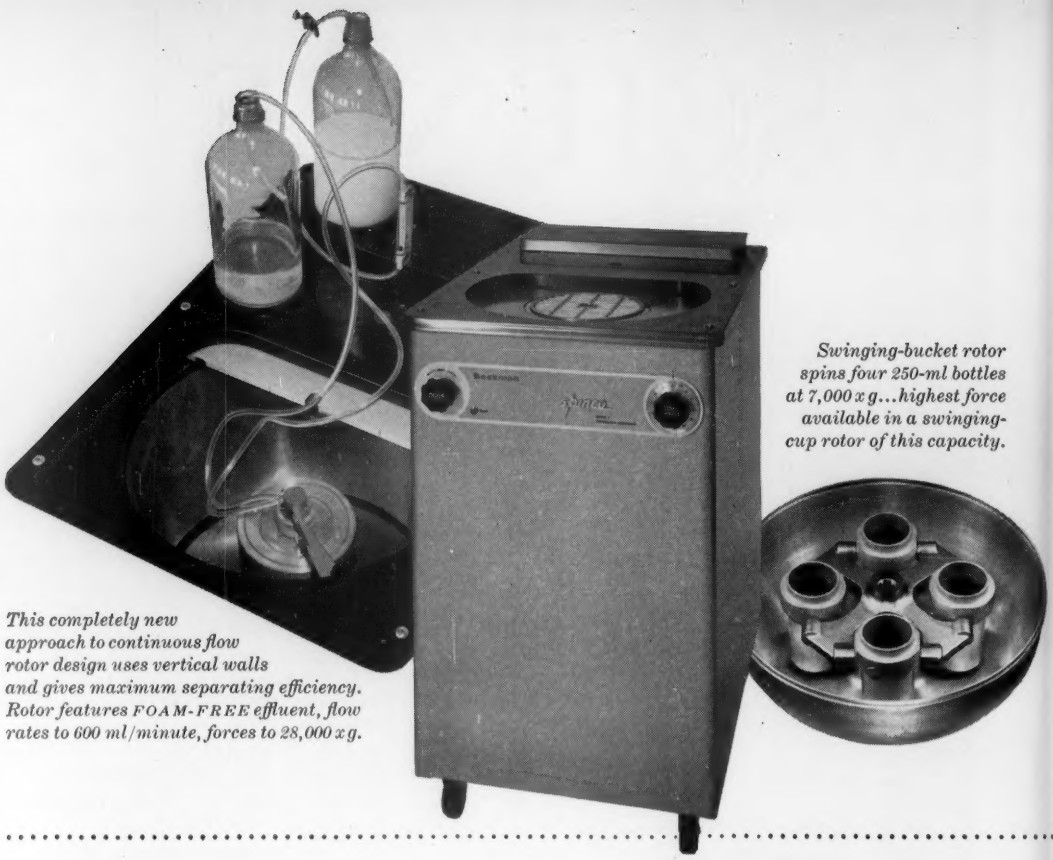

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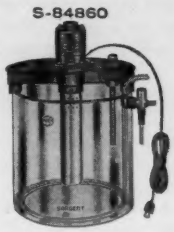

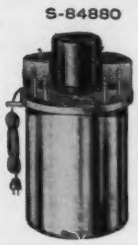

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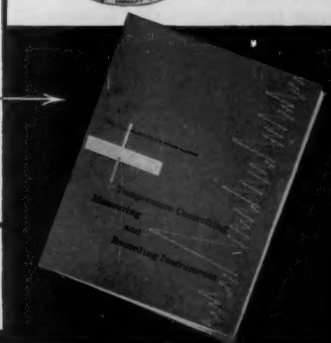

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Letters

Hazards from Isotopic Tracers

There is an aspect of the use of radioisotopes as tracers which needs to be called to the attention of some of those people using them. This is, that the degree of hazard involved, both to the investigator and to any volunteer subjects, can depend to a great extent on the chemical form in which the isotope is used, and that, to a large degree, the present guides for estimating this hazard are inadequate.

The immediate example is the rapidly growing use of tritiated thymidine and other nucleic acid precursors. The estimates of the hazard from tritium are based on the assumption that it is used in the form of tritiated water. In this case, it is estimated that tritium distributes uniformly through about 50 liters of water in the "standard man," and that it turns over with a biological half-life of 19 days [see "Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water," *Natl. Bur. Standards (U.S.) Handbook No. 52*]. Under these conditions, it is estimated that a steady burden of 10 mc of HTO in the body, or of 200 μc per liter of drinking water, would deliver 300 mrem per week. If one considers the "integral dose" from a single intake of HTO, the estimate is that about 1 c is required to deliver a total dose of 100 rem [see, for example, K. Z. Morgan, in *Proc. 1st Intern. Conf. on the Peaceful Uses of Atomic Energy* (1956), vol. 13, p. 139]. On this basis, the Atomic Energy Commission now allows the sale of 250 μc of tritium without a specific license. In the form of tritiated water, swallowed or inhaled all at one time, this quantity would deliver between 20 and 35 mrem, a reasonable risk indeed for an investigator.

One is also permitted, however, to buy 250 μc of tritiated thymidine without a specific license. The experimental results obtained so far, with this and other isotopic tracers, show that in some organisms thymidine goes largely, if not exclusively, into deoxyribonucleic acid (DNA) and that it stays there with little if any turnover. This points up the fact that investigators need to take considerable precaution in handling the material. One can estimate that the human body contains 50 to 100 g of DNA, or, say, 1000 times less DNA than it does water. The biological half-life may be very long, depending on the cells and tissues most actively synthesizing DNA, and it is conservative to estimate a half-life of 190 days or more—perhaps years? If all the radiation were concentrated in the DNA itself, 250 μc of tritium could deliver to the "genestuff" a dose 10,000 to 100,000 times greater than that from an equal quantity in the form of tritiated water.

Other factors affect this estimate, however. The first is that, in fact, the ionizations are spread through a somewhat larger volume than just the DNA (most of the ionizations being within 1 or 2 μ of their origin), so that the dose (ionizations per unit volume) is lower. A more correct estimate, then, is that the chromosomes or entire nuclei are being irradiated, and the dose may be 10 to 50 times less than that estimated above. The second factor—namely, the fact that a small fraction of the body cells are most actively synthesizing DNA (for example, the germ lines, bone marrow, spleen, and so on)—works in the opposite direction. If these cells pick up most of the tritium, the dose may be increased by a factor of 10 or more—not to mention the fact that these cells are more radiosensitive than others. The last consideration is that only a fraction of the thymidine will be incorporated into DNA—depending on the route of intake, somewhere between 1 and 50 percent (?).

Putting all these factors together, one estimates that under various conditions tritiated thymidine can deliver a dose to the chromosomes of radiosensitive cells from 50 to 50,000 times greater than that delivered by an equal activity of tritiated water. The upper limit corresponds to about 5 r per microcurie ingested. In view of the unusual difficulty of monitoring tritium contamination, it seems clear that great care needs to be taken by anyone who wants to use tritium in the form of thymidine.

The foregoing estimates are very uncertain, and the information is not yet available to improve them. Similar considerations apply to any other specialized metabolite; much more information is needed about the fates of isotopic tracers. Frequently the investigators who use them are best qualified to determine these fates, and it is to be hoped that they will do so and make the information available to guide others.

W. R. GUILD
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Survival

In a letter headed "Darwin and Pandora's box" [*Science* **128**, 424 (1958)], H. K. Livingston discusses the analogy between the death of the individual and the extinction of species, with reference to the concept of immortality. He asserts that "one consequence of the understanding gained from our concept of evolution is the knowledge that species become extinct—not just occasional species, as an odd incident, but all species, inevitably, as part of the order of things." This statement can hardly be supported by direct observational evidence; indeed, there are many species alive today with fairly remote origins, and we really do not know whether there is an upper limit to the "life-time" of a species. George Gaylord Simpson [*The Meaning of Evolution* (Mentor, New York, 1951), p. 76] has considered this problem:

"Is extinction the fated end of all groups of organisms, as death is of each individual organism? There are in the world today a large number of types of organisms that arose so long ago that the great majority of their early contemporaries have long been extinct. . . . Among these Methuselahs . . . are . . . *Sphenodon* (surviving almost unchanged from Jurassic to Recent) or the opossum (Cretaceous to Recent). The invertebrates, older to begin with and generally slower in evolution, provide still more striking examples. The little sea shell *Lingula* is amazingly like its Ordovician ancestor of 400,000,000 years or so ago, and an oyster of 200,000,000 years or more in the past would look perfectly familiar if served in a restaurant today."

Simpson points out the special circumstances which have allowed these types to continue so long, and adds: "The fact that extinction has not occurred for these animals during their exceptionally long histories does not permit the conclusion that their extinction will never occur and that they are, in literal fact, immortal. . . . It must be concluded that material racial immortality is impossible. The time will come when all life ends." Here he adds a footnote: "The fantasy of transfer to other planets is not impossible although it is hardly imminent. This might postpone but could not avoid the inevitable end."

Inasmuch as any cosmic catastrophe, such as a radical change in the luminosity of the sun, is not expected for several billion years, it appears to be possible, if not probable, that *Homo sapiens* or his descendents might survive on this planet for a period of time comparable to the interval during which life has existed. By that time, "the fantasy of transfer to other planets" should be a practicality; if the steady-state view of the universe is the correct one, there should then be no "time . . . when all life ends."

As for the problem of surviving for the next few billion years on this planet, it is tempting to extend the analogy between the life of the individual and the life of the species. Just as man's intelligence has allowed him to extend the life of the individual, it can be hoped that his intelligence, used wisely, can prolong his existence as a species—perhaps indefinitely.

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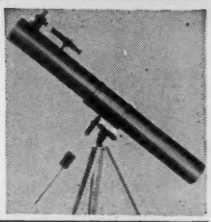

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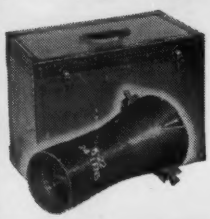

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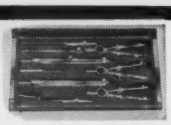

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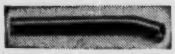

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Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts, book reviews, and illustrations, see *Science* 125, 16 (4 Jan. 1957).

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Fiscal Control of Research

The university scientist, like his department head and his president, values unrestricted funds that he can use as the changing requirements of his research determine. Traditionally he has had such funds, frequently in small amount but with freedom to plan his own research and to alter his plans as he thought best. Now, however, with the increased cost of many kinds of research, the changing pattern of research support, and the great amount of research money coming from the Federal Government, some of this earlier freedom has been lost, the comptroller is challenging the research director, and there are beginning to be complaints from the campus that have a discouragingly familiar ring to one acquainted with government operations: plans must be submitted in advance so that they can be reviewed and approved at higher administrative levels; if changes become necessary, the changes must also be reviewed; decisions—typically negative or curtailing decisions—are frequently made by administrators who are far from the laboratory but close to the seat of over-all fiscal responsibility.

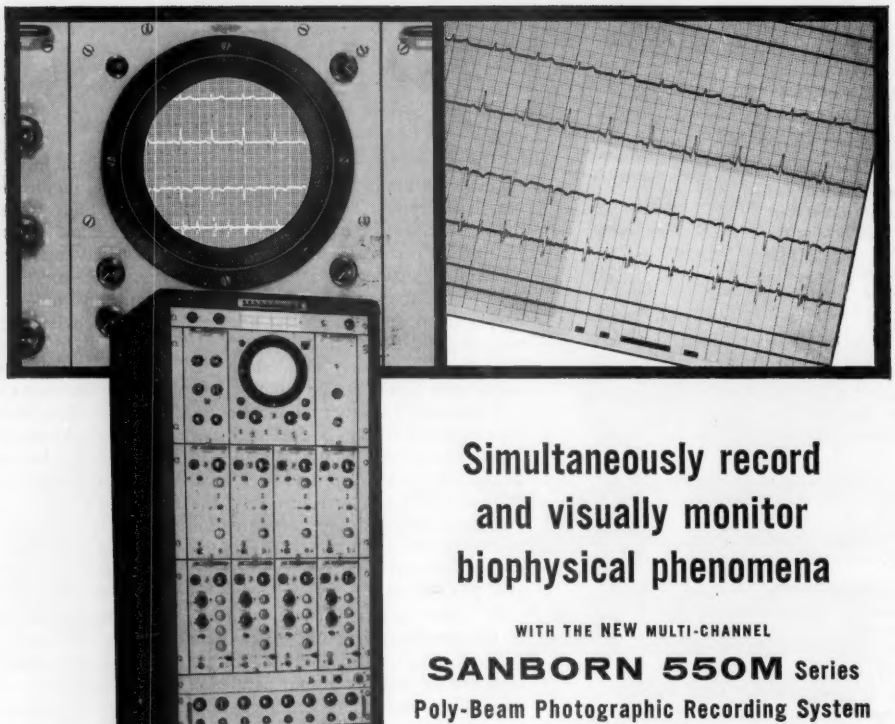
This whole process stems from the fact that where large amounts of money are involved, the "safe" step for each person in the line of authority to take is to insist upon reviewing the plans and expenditures of persons under his supervision. The resulting multiplicity of reviews is costly in manpower, in frustration, and in inevitable and sometimes protracted delay.

In applied or developmental research, these costs can become very great. A Congressional committee has severely criticized the Department of Defense for a management system that sometimes requires a project to be reviewed by as many as four parallel offices, as many as three times by the same office, and by a distressingly large number of individuals in different offices and at different administrative levels. A current topic in many discussions of military management is the extent to which this system has produced dangerous delays in the development of new weapons.

A basic fault with the whole process of multiple review is that authority to make decisions is divorced from the responsibility for carrying out those decisions. Decisions concerning weapon design are made at headquarters levels, but the contractor must build the weapons and see that they meet performance specifications. Some decisions concerning research plans are made at administrative levels, but the laboratory scientist must carry out the research.

In a general way, it is probably true that the larger the organization the greater is the pressure for centralized control. But the pressure can be resisted, and some administrators have learned that close attention to how each dollar is spent increases the total number of dollars necessary to accomplish a given end. Thus some large industries have learned the effectiveness of decentralizing authority as well as responsibility. The National Institutes of Health and the National Science Foundation provide some excellent examples of minimal review of project plans and changes. Congress recently extended the right to make grants, as opposed to research contracts, throughout the research-supporting agencies of government. Farther afield, the British Parliament accepts from the Department of Scientific and Industrial Research a budget document so slim that it hardly equals the introduction to the budget justification that the National Science Foundation submits to Congress. (For fiscal 1959 that document weighed three and a half pounds.)

Good business management is essential in universities, but it will be strange indeed if university research management follows the stultifying road of bureaucratic review and review and review when that road is so foreign to university traditions and when there are effective and much more congenial roads to follow.—D.W.



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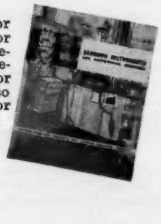

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28 November 1958, Volume 128, Number 3335 SCIENCE

Ancestor of Corn

A genetic reconstruction yields clues to the nature of the extinct wild ancestor.

Paul C. Mangelsdorf

Our purpose in reconstructing the ancestor of corn is to retrace, so far as possible, some of the principal steps which have been involved in its evolution under domestication. We do this in the hope of gaining a better understanding of the corn plant as one of those unique biological systems which man employs on a grand scale to convert the energy of the sun, the carbon dioxide of the air, and the minerals of the soil into food. Corn is one of perhaps not more than a dozen species of cultivated plants of world-wide importance—each one the principal source of food of millions of people—which quite literally stand between mankind and starvation.

But corn is something more than an important food plant; it is also a mystery, a fascinating botanical mystery, as challenging to a scientist as is a mountain to an explorer.

A Unique Cereal

Modern corn, our starting point in this study (*1*), is unique among the cereal grasses in the nature of its inflorescences (*2, 3*). The terminal inflorescence, commonly called the "tassel" (Fig. 1*A, C*), usually bears only male flowers, each of which contains three pollen sacs or anthers (Fig. 1*D*) packed tightly with some 2500 pollen grains. These are small, about 1/250 inch in diameter, light in weight, and are easily carried by the wind.

The lateral inflorescences (Fig. 1*A, B*), which when mature become the familiar ears of corn, have only female flowers which bear the pollen-receptive organs commonly known as the "silks." These are covered with fine hairs and are admirably designed to capture wind-blown pollen (Fig. 1*E*). Thus corn, in contrast to the majority of cereals, is a naturally cross-pollinated plant. It is this feature which makes possible the production of hybrid corn, one of the most spectacular developments in applied biology of this century.

Each silk represents a potential kernel and must be pollinated in order for that kernel to develop. The kernels themselves are firmly attached to a rigid axis, the cob, and are not covered as are those of other cereals by the floral bracts which botanists call "glumes" and which the layman knows as "chaff." Instead the entire ear is enclosed, often quite tightly, by modified leaf sheaths, the husks or shucks (Fig. 1*B*). Thus, while in other cereals the kernels are protected individually, in corn they are covered en masse. The result is that cultivated corn has no mechanism for the dispersal of its seeds and hence is no longer capable of reproducing itself without man's intervention. The very characteristics which make corn so useful to man render it incapable of existing in nature, and it is probable that corn would quickly become extinct if deprived of man's protection.

How, then, did corn's wild ancestor differ from cultivated corn in ways which enabled it to exist in nature for thousands, if not millions, of years before man appeared on the scene? This is one of the questions which we hoped to answer by reconstructing the ancestral form. Our reconstruction is based in part upon fossil and archeological remains and in part upon genetic recombination of some of the primitive characteristics which still exist in modern corn varieties.

Fossil Corn Pollen

The fossil evidence comprises a number of pollen grains isolated from a drill core taken from a depth of more than 200 feet below the present site of Mexico City. These were recognized as unusually large pollen grains of a grass by Paul Sears of Yale University and Kathryn Clisby of Oberlin College, who, in connection with charting climatic changes, were engaged in pollen studies of the drill core. The pollen was identified by Elso Barghoorn (*4*) of Harvard University as that of corn, which has the largest pollen of any known grass. Although assigned to the last interglacial period and therefore, on the basis of recent estimates, probably at least 80,000 years old, the fossil pollen is scarcely distinguishable in size, shape, and other characteristics from modern corn pollen (Fig. 2). This fact leaves little doubt that the ancestor of corn was corn and not one of its two American relatives, teosinte or *Tripsacum*.

Oldest Cultivated Corn

The oldest known remains of cultivated corn come from a once-inhabited rock shelter in New Mexico known as Bat Cave, which was excavated by Herbert Dick, of the Peabody Museum of Harvard University and later of the Colorado University Museum, in two expeditions, in 1948 and 1950 (*5, 6*). This cave was inhabited for several thousand years by people who practiced a primitive form of agriculture and an even more primitive pattern of sanitation.

The author is professor of botany at Harvard University. This article, adapted from a paper presented at the annual meeting of the American Philosophical Society in Philadelphia on 25 April 1958, is reprinted, with permission, from the *Proceedings* of the Society.

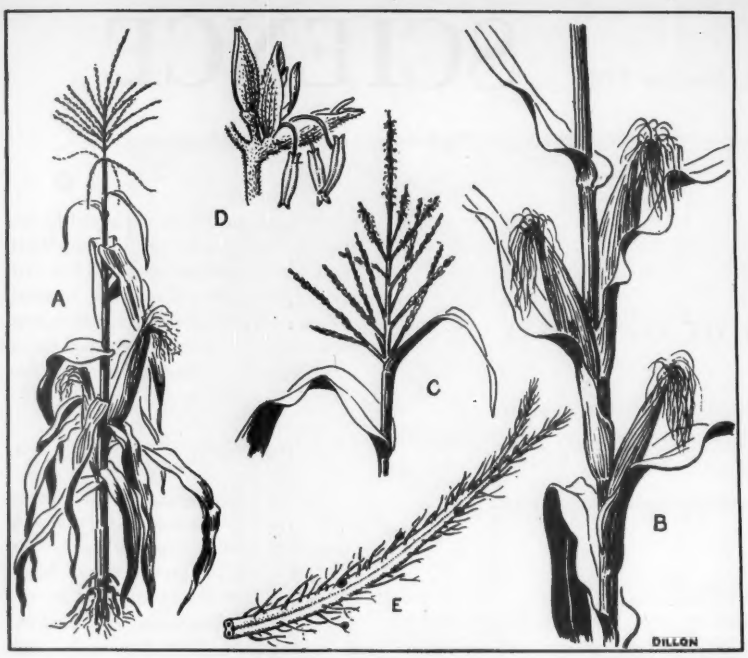

Fig. 1. Botanical characteristics of the modern corn plant. (*A*) The entire plant, showing the male inflorescence, the tassel, at the tip of the stalk and the female inflorescences, the ears, in the middle region; (*B*) young ears enclosed in husks with the pollen-receptive organs (the silks) protruding from the ends; (*C*) typical tassel; (*D*) typical male flower with three anthers containing pollen; (*E*) a single silk magnified to show hairs and adhering pollen grains. [From P. C. Mangelsdorf, "Corn" (*3*), by permission of *Encyclopaedia Britannica*]

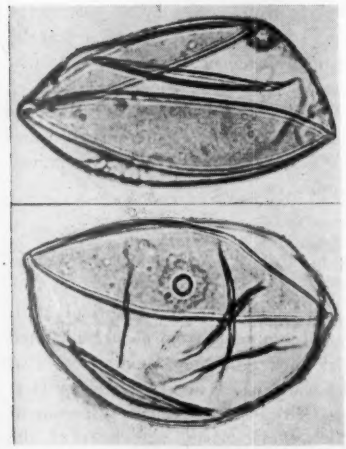

Fig. 2. Fossil pollen of corn (top) from more than 200 feet below the present site of Mexico City compared with a pollen grain of modern corn (bottom) at the same magnification. In spite of some 80,000 years' difference in their ages, these two pollen grains are virtually identical in their characteristics, and they show that the ancestor of corn was corn and not one of its two American relatives, teosinte or *Tripsacum* (×375). [From Barghoorn *et al.*, "Fossil maize from the Valley of Mexico" (*4*)]

During the centuries of their occupancy, garbage, excrement, and other debris accumulated in the cave to a depth of six feet, creating exactly the kind of site which archeologists delight to dig into. At the bottom of this accumulation of trash, Dick turned up some tiny cobs of ancient corn which have been dated, on the basis of Willard Libby's radiocarbon determinations of associated charcoal, at about 5600 years.

Three of these ancient cobs are compared in Fig. 3 with a one-cent piece whose diameter is about equal to their length. One of the tiny specimens is compared in Fig. 4 with ears of two modern races of corn: the dent corn of the United States corn belt and a large-seeded flour corn of Peru. How could a corn like the Bat Cave corn have evolved into these and other modern races even in 5600 years? This is the principal question which we hoped to answer by retracing some of the steps involved in corn's evolution under domestication.

Since there were no living seeds of the Bat Cave corn it was impossible to work forward experimentally from it to modern corn. The alternative was to work backward from present-day corn by combining primitive characteristics still occurring in living varieties. But what characteristics of corn are primitive? My associate, W. C. Galinat, and I sought to determine this by an intensive study of one of the Bat Cave specimens which contained the partial remains of a single kernel. Each part of this cob was carefully dissected out and measured. On the basis of the measurements, Galinat prepared the diagrammatical, longitudinal section illustrated in Fig. 5. The tiny kernels which this cob must once have borne could only be those of popcorn, a type in which the kernels are small and hard and capable of exploding when exposed to heat. The long stems or pedicels on which the kernels were borne and the long floral bracts which almost completely enclosed them show that the Bat Cave corn was also a form of pod corn, a type in which the individual kernels are enclosed in pods or chaff.

It is interesting to note in this connection that the late E. Lewis Sturtevant, a long-time student of corn, concluded many years ago that both popcorn and pod corn are primitive. My former colleague, R. G. Reeves, and I (*7*) later reached a similar conclusion. The ancient Bat Cave specimens provide convincing archeological evidence in support of these conclusions.

Crossing Primitive Corns

What we have done, then, is to cross a number of varieties of popcorn from various parts of the world with pod corn (Fig. 6), which still occurs as a "rogue" or "freak' in some South American va-

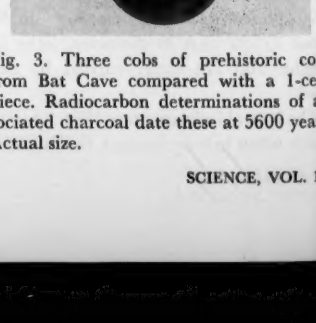

Fig. 3. Three cobs of prehistoric corn from Bat Cave compared with a 1-cent piece. Radiocarbon determinations of associated charcoal date these at 5600 years. Actual size.

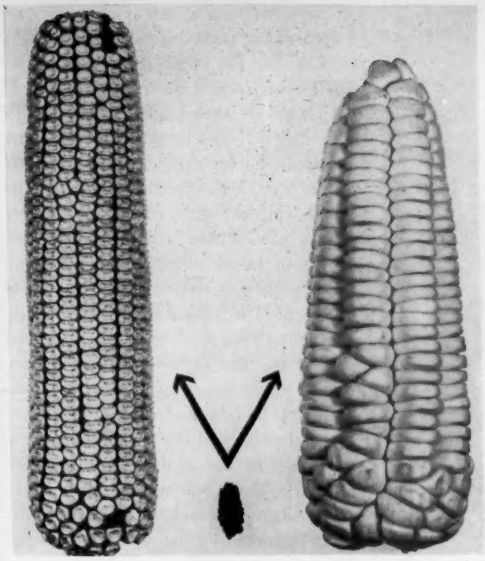

Fig. 4. One of the Bat Cave cobs (center) compared with a modern ear of Corn-belt dent (left) and a large-seeded Peruvian flour corn (right). Extremely rapid evolution has been involved in producing such drastic changes even in 5600 years, the estimated difference in age.

rieties and which in some localities is preserved by the Indians, who believe it to have magical properties. Pod corn has also sometimes been grown in gardens in the United States as a curiosity. Today it is most likely to be found in the experimental cultures of corn geneticists, who maintain it as one of the "marker" genes on the fourth longest chromosome of corn.

There is no doubt that pod corn is primitive in its characteristic of enclosing the kernel in glumes or chaff, as do all other cereals and virtually all other grasses. Despite this fact, and because it is often monstrous and sometimes sterile, it has been dismissed by a number of botanists from any role in the ancestry of corn (*8*). We believe that its monstrousness has been misunderstood—that pod corn is monstrous today only because it is a "wild" relict character superimposed upon modern highly domesticated varieties. Today's pod corn is comparable to a 1900 chassis powered by the engine of a 1958 car. The surprising thing is not that pod corn is sometimes monstrous but that it is not more so—that the particular genic locus which governs its expression is capable of functioning at all in a milieu so different from that in which it was undoubtedly well adapted. We have assumed that pod corn would be less monstrous and would exhibit normal grass characteristics when combined with other "wild" genes, and we hoped to find these in varieties of popcorn.

Our hopes have been realized. Popcorns in general tend to reduce the monstrosity of pod corn when crossed with it, and some varieties do so quite drastically. The varieties Lady Finger and Argentine carry complexes of modifying genes which appreciably reduce the monstrosity of pod corn, and a third variety, Baby Golden, carries a major modifying gene which, on the basis of preliminary linkage tests, appears to be on the sixth chromosome and which acts as an inhibitor of pod corn, reducing its expression by approximately half.

By combining these modifying and inhibiting genes from several popcorn varieties with the pod-corn gene, we have developed a number of strains of popcorn which, having this gene present on both of their fourth chromosomes, breed true for the pod-corn character. Some of these homozygous strains are much less monstrous than the usual forms of pod corn, are completely fertile, and might under suitable conditions be capable of surviving in the wild.

Effects of a Single Gene

The majority of these true-breeding pod-popcorns have other characteristics which we may now regard as primitive. The plants, when grown on fertile soils, instead of having one stalk, as do most modern corns, have several (Fig. 7) and in this respect resemble the majority of wild grasses, including all of the known relatives of corn, both American and

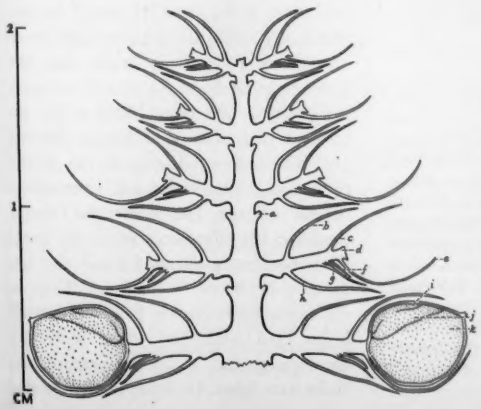

Fig. 5. Diagrammatic longitudinal section of one of the Bat Cave cobs, based on measurements of dissected parts. The tiny kernels show that this was a popcorn; the long pedicels on which the kernels are borne and the bracts which almost enclose them indicate that it was also a pod corn [W. C. Galinat]

Fig. 6. An ear of Argentine popcorn (left) and an ear of present-day pod corn (right). Popcorn is primitive in having small hard seeds. Pod corn is primitive in having its seeds enclosed in pods or chaff, like the other cereals. These two types were crossed in order to combine their primitive characteristics.

Fig. 7. Three plants of a many-stalked popcorn differing with respect to the pod-corn gene. The first plant (left) lacks this gene; the second (center) has it on one member of the fourth chromosome pair; the third (right) has the gene on both members of the fourth chromosome pair. The progressive decrease in height is associated with the pod-corn gene, which causes, among other effects, a shortening of the internodes of the upper part of the stalk.

Fig. 8. A tassel and ear of a true-breeding pod corn. The shortening of the internodes of the upper part of the stalk causes or is accompanied by a tassel which bears both male and female flowers. The withered silks immediately below the tassel are from female flowers on the tassel branches which bloomed several weeks before this photograph was taken. Several seeds, resulting from pollination of these flowers, are visible. Such seeds are easily dispersed when mature by the breaking of the fragile tassel branches. The fresh silks to the left of the tassel are from a subtassel ear which is enclosed in husks when young but can emerge from them and disperse its seeds when mature. The silks of this ear can be pollinated by pollen from the anthers in the tassel of the same plant, but the female flowers in the tassel can receive pollen only from another plant. Thus, the reconstructed primitive corn plant has devices for both self- and cross-pollination.

Asiatic. The plants are shorter than ordinary corn because one of the numerous effects of the pod-corn gene is to shorten and thicken the upper internodes of the stalk. This is well illustrated in Fig. 7, which shows three plants of popcorn in one family: one lacking the pod-corn gene, one having the gene on one member of its fourth chromosome pair, and one having the gene on both members of the pair. There is a progressive decrease in height through this series of three genotypes resulting from a shortening of the upper internodes. This shortening causes, or at least is accompanied by, the development of a terminal inflorescence which bears both male and female flowers, the male flowers at the tips and the female flowers at the bases of the same tassel branches (Fig. 8). These branches are quite brittle when mature and break apart easily when disturbed by the wind or by birds. They thus provide one of the most important primitive characteristics which cultivated corn lacks: a mechanism for the dispersal of seeds.

Position of the Ear

Plants of homozygous pod corn frequently do not have ears—most of their energy is apparently concentrated in the terminal inflorescences—but when they do have ears these are usually borne high upon the stalk (Fig. 8), often at the joint of the stem immediately below the tassel. This elevation of the position of the ear has profound effects which are illustrated by the diagram in Fig. 9. The diagram, which is based on data from several many-eared plants, shows how a number of the characteristics of the ears are determined by their position on the stalk: (i) The higher the position, the smaller the ear, partly for the simple mechanical reason that the stalk at this position is slender and is incapable of bearing a heavy load. It would be mechanically impossible for the large modern ear of corn to be borne near the slender tip of the stalk. (ii) The higher the position, the more likely is the ear to have both male and female flowers. (iii) The higher the position, the shorter the lateral branch or "shank" upon which the ear is borne. The shorter the branch, the fewer the joints from which the husks arise, the fewer the husks and the less completely the ear is enclosed. Thus an ear borne immediately below the tassel is enclosed while the young seeds are developing, but as these mature the husks flare open, allowing the ear to dis-

perse its seeds. In short, a simple change in position determined by a single gene change can provide a mechanism for dispersal of the seeds borne on the ear as well as those borne on the fragile branches of the tassel.

These facts seem to answer several of the most puzzling questions involved in previous attempts to explain corn's evolution: How could wild corn have survived the handicap of an ear incapable of dispersing its seeds? And if wild corn had no ears, how could the ear of modern corn, its most important organ, have come into existence?

The position of the ear has an effect on still another characteristic illustrated in Fig. 9, the length of the streamers or leaf blades which in many varieties terminate the outer husks. The higher the ear, the more likely are the leaf blades to be short or absent. This may explain the absence of leaf blades in prehistoric husks found both in Bat Cave (*6*) and in La Perra Cave (*9*).

Fig. 9. Diagrammatic longitudinal section based on data from several plants of a many-eared corn stalk, showing how the position of the ear on the stalk affects its characteristics. The higher the ear, the smaller its size, the fewer its husks, and the more likely it is to bear both male and female flowers. [W. C. Galinat]

Modern and Primitive Corn Compared

The most primitive ear we have so far obtained by combining popcorn and pod corn is shown in Fig. 10 in comparison with an ear of modern dent corn and with the most primitive cob, dated at 4445 ± 180 years, from La Perra Cave, which was excavated by Richard MacNeish of the National Museum of Canada.

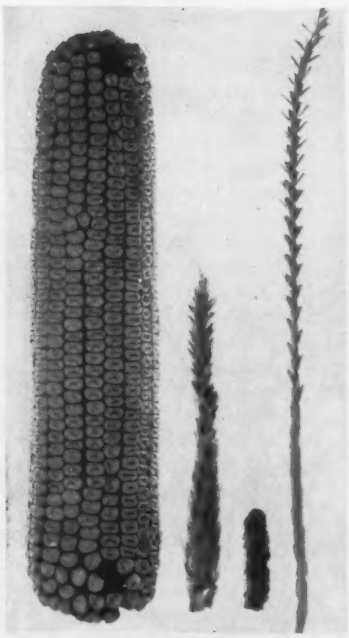

Fig. 10. The reconstructed ancestor of corn, an ear of pod-popcorn (second from left) compared with a modern ear of dent corn (far left) and a prehistoric cob of La Perra Cave corn (second from right). The dent corn weighs 317 grams; the reconstructed ear 1.99 grams. The reconstructed ear has female flowers below and male flowers above and in this respect resembles a spike of *Tripsacum* (far right), a wild relative of corn. The La Perra cob also once had a male portion, which has been lost; only the stump of its stem still remains. Without its kernels and male spike, the reconstructed ear would weigh 0.87 gram—only slightly more than the La Perra cob, which weighs 0.52 gram.

In weight and number of kernels our reconstruction is much closer to the prehistoric La Perra specimen than to the ear of modern dent corn. The modern ear weighs 317 grams. The ear of pod-popcorn weighs 1.99 grams. However, only 24 of its 38 female flowers developed kernels. Had all done so, it would weigh 2.47 grams, assuming the additional kernels to have the same average weight, 0.034 gram, as those which are present. The La Perra specimen weighs only 0.52 gram, but it lacks both the 48 kernels, which it once bore, and a male spike. Without its kernels and its male spike, the reconstructed ancestral form weighs 0.87 gram, only slightly more than the prehistoric specimen.

Although we have not yet completely reconstructed wild corn, nor duplicated exactly the most primitive specimens from either Bat Cave or La Perra Cave —the glumes of the pod-popcorns are

Fig. 11. A prehistoric Zapotec funerary urn from Mexico with two representations of primitive corn ears in the headdress and one in the hands of the maize god.

Fig. 12. Details of one of the ears shown in Fig. 11. It is probable that the slender column above the small ear was intended to represent the male spike of a prehistoric ear similar in some of its characteristics to the reconstructed ancestral form illustrated in Fig. 10.

still too prominent to match those of the prehistoric specimens—we have succeeded in developing what is probably the world's most unproductive corn. This is useful in suggesting that we are on the right track in attempting to retrace corn's evolutionary paths.

The reconstructed ear illustrated in Fig. 10 has female flowers on its lower half and male flowers on the remainder. This, as Fig. 9 shows, is a characteristic of ears borne in a high position on the stalk. If our reconstruction is valid, should not prehistoric ears also bear male flowers? A reexamination under the microscope shows that at least some of them once did and that these have since been lost in handling. Some of the ancient cobs, including the one illustrated in Fig. 10, have stumps, previously unnoticed, of a slender stem on which male flowers were undoubtedly borne. Thus our genetically reconstructed ancestral form has taught us to look for a characteristic in prehistoric ears which we had previously overlooked. It has also shown us the significance of ears bearing terminal male spikes which are still found in certain races of corn in the countries of Latin America: the races Nal-Tel and Chapalote of Mexico (*10*), Pollo of Colombia (*11*), and Confite of Peru. Finally it may explain some curious ears, which had previously puzzled us, moulded in bas relief on a prehistoric Zapotec funerary urn from Mexico. The urn is shown in Fig. 11, and the details of one of the ears in Fig. 12.

In bearing both male and female flowers these ears of pod-popcorn also resemble the lateral inflorescences of *Tripsacum*, a perennial grass and a wild relative of corn (Fig. 10). This resemblance has in turn called attention to additional characteristics in which the reconstructed corn resembles *Tripsacum*: (i) the flowering of the female spikelets before the male in both lateral and terminal inflorescences; (ii) the many-stalked condition; (iii) the small, hard, pointed seeds.

Fig. 13. Environmentally induced and genetically controlled variation in the corn plant. Plants (from left): (i) a plant of pod-popcorn as it might have grown in nature in a poor site in competition with other natural vegetation; (ii) the same, grown under primitive agricultural conditions; (iii) the same, grown in a fertile site free of competition with weeds (this plant is essentially the same as the plant at right in Fig. 7); (iv) a popcorn plant which has lost the pod-corn gene (this is the counterpart of the plant at left in Fig. 7); (v) New England flint corn, in which human selection for larger ears has tended to eliminate the secondary stalks, reducing them to "suckers"; (vi) Cornbelt dent corn, in which the trend noted for (v) has been carried still further; Cornbelt dent corn is usually single-stalked, commonly bearing a single large ear in the middle region of the stalk. The middle position of the ear has both mechanical and physiological advantages over a terminal position and probably accounts for corn's superiority over other cereals in its capacity to produce grain. [W. C. Galinat]

Actually this reconstructed corn might easily be classified an an annual form of *Tripsacum,* or conversely, since corn was the first of the two to be given a Latin name, *Tripsacum* could be classified as a perennial form of the genus *Zea,* to which corn belongs and which, until recently, has been represented by the single species *Zea mays.*

These unexpected results of combining popcorn and pod corn—the production of a counterpart of corn's wild relative, *Tripsacum*—we regard as additional evidence that our reconstruction has validity.

Evolution under Domestication

Figure 13 illustrates some of the principal environmentally induced and genetically controlled changes which are believed to have occurred during domestication. The first three plants illustrate the genetically reconstructed ancestral form as it would be expected to develop in three different environments. The first plant, a short, single-stalked plant with a slender, unbranched tassel bearing both male and female flowers and no ears, is intended to represent the wild corn plant growing in nature in a site of low fertility and in severe competition with other natural vegetation. Such a plant would barely reproduce itself.

The second plant represents this same genotype grown under primitive agricultural conditions. Here it it still single-stalked but under these somewhat better conditions is capable of producing a branched tassel and a single small ear borne high upon the stalk. The third plant (a counterpart of the third plant in Fig. 7) represents the genetically reconstructed ancestral form grown under modern agricultural conditions with an abundance of fertilizer and in freedom from competition with weeds. Under these conditions it has several stalks as well as several small ears on each stalk. Plants like these might also have occurred sporadically in the wild under unusually favorable natural conditions.

The ability of the wild corn plant to respond in a spectacular fashion to freedom from competition with weeds and to high levels of fertility is undoubtedly one factor which led to its domestication. This ability to take full advantage of the improved environment usually afforded by an agricultural system is one of the characteristics found in almost all highly successful domesticated species. There are many wild species which do not have this trait; they cannot stand prosperity.

Since the corn plant is genetically plastic as well as responsive to an improved environment, domestication may soon have brought other changes, which are illustrated in the last four plants in Fig. 13. One of the most important of these was a mutation at the pod-corn locus on the fourth chromosome. This single genetic change had numerous effects. It reduced the glumes which in wild corn completely surrounded the kernels, and the energy released from chaff production now went into the development of a larger cob, which in turn bore more and larger kernels. The mutation also lowered the position of the lateral inflorescences, and this had profound effects of several kinds which can be understood by referring again to Fig. 9. This shows that: (i) the lower the ear, the stronger the stalk at the position at which the ear is borne and the greater its capacity for supporting large ears. (ii) The lower the ear, the more likely it is to bear only female flowers which develop kernels when pollinated. (iii) The lower the ear, the longer the shank, the branch on which it is borne, and this in turn has a number of important secondary effects: the longer the shank, the more numerous its nodes or joints and the husks which arise from them; the greater the number of husks, the more completely the ear is enclosed and the less capable it is of dispersing its seeds.

In short, a rather simple change but a very important one, the lowering of the position of the ear (comparable, perhaps, to moving the engine of a primitive airplane from a position behind the wings to one in front of them), has separated the sexes, and made for a larger, strictly grain-bearing ear which is completely protected by the husks and is no longer capable of dispersing its seeds. In short, a mutation at a single locus on chromosome 4 has made the corn plant less able to survive in nature but much more useful to man.

The last two plants in Fig. 13 show some of the changes which human selection has subsequently effected. Selection for large ears has tended to eliminate the secondary stalks and to reduce the number of ears per stalk. The fifth plant in Fig. 13 represents a typical New England flint corn in which the secondary stalks have been reduced to low tillers, known to the farmer as "suckers," which in days of cheaper labor were often removed under the erroneous impression that their removal was a kind of beneficial pruning operation. The last plant represents a typical Cornbelt dent corn which is predominantly single-stalked and often bears only one ear, in approximately the middle region of the stalk.

The corn plant has a distinct advantage over other cereals in bearing its ears in the middle region of the stalk, which, being thicker and stronger than the tip, is capable of supporting a larger ear. This is a simple and obvious mechanical advantage. There may also be a less obvious but even more important physiological advantage. We have evidence (*12*) that, under otherwise constant conditions with respect to the genotype and the environment, a decrease in the weight of the tassels may be accompanied by an increase five times as great in the weight of the ears. There is at least little doubt that corn, by virtue of its botanical characteristics, is potentially more productive than the other cereals. For example, record yields of wheat seldom exceed 100 bushels per acre; the maximum yields of corn recently reported are more than 300 bushels per acre.

There have, of course, been other factors, not discussed here, in corn's evolution under domestication: mutations at many loci in addition to that governing the characteristics of pod corn; extensive hybridization among distinct races (*10, 11*); repeated hybridization with teosinte (*9, 13*) and perhaps also with *Tripsacum* (*7*); and human selection for many different characteristics. But it was this one mutation at the pod-corn locus—this single change in a molecule of the hereditary material—which more than any other factor has determined the botanical characteristics of modern corn and which set the plant upon new evolutionary paths that have made it more useful to man and more dependent upon him for survival.

References and Notes

1. The research reported in this article was supported in part by a grant from the National Science Foundation. I am indebted also to Dr. Walton C. Galinat for his assistance in some aspects of these studies as well as for the drawings reproduced in Figs. 5, 9, and 13.
2. O. T. Bonnett, "The inflorescences of maize," *Science* 120, 77 (1954); P. Weatherwax, "Structure and development of reproductive organs [of corn]," in *Corn and Corn Improvement* (Academic Press, New York, 1955).
3. P. C. Mangelsdorf, "Corn," in *Encyclopaedia Britannica* (1958).
4. E. S. Barghoorn, M. K. Wolfe, K. H. Clisby, "Fossil maize from the Valley of Mexico," in *Botan. Museum Leaflet Harvard Univ. No. 16* (1954), pp. 229–240.
5. P. C. Mangelsdorf, "New evidence on the origin and ancestry of maize," *Am. Antiquity* 19, 409 (1954).
6. ——— and C. E. Smith, Jr., "New archaeo-

logical evidence on evolution in maize," in *Botan. Museum Leaflet Harvard Univ. No. 13* (1949), pp. 213–247.
7. P. C. Mangelsdorf and R. G. Reeves, "The Origin of Indian Corn and its Relatives," *Texas Agr. Expt. Sta. Bull. No. 574* (1939).
8. P. Weatherwax, *Indian Corn in Old America* (Macmillan, New York, 1954); —— and L. F. Randolph, "History and origin of corn," in *Corn and Corn Improvement* (Academic Press, New York, 1955).
9. P. C. Mangelsdorf, R. S. MacNeish, W. C. Galinat, "Archaeological evidence on the diffusion and evolution of maize in northeastern Mexico," in *Botan. Museum Leaflet Harvard Univ. No. 17* (1956), pp. 125–150.
10. E. J. Wellhausen, L. M. Roberts, E. Hernandez, in collaboration with P. C. Mangelsdorf, *Races of Maize in Mexico* (Bussey Institution, Harvard Univ., Cambridge, Mass., 1952).
11. L. M. Roberts, U. J. Grant, R. Ramirez, W. H. Hatheway, D. L. Smith, in collaboration with P. C. Mangelsdorf, "Races of Maize in Colombia," *Natl. Acad. Sci. Natl. Research Council Publ. No. 510* (1957).
12. A report on this evidence is in preparation.
13. W. C. Galinat, P. C. Mangelsdorf, L. Pierson, "Estimates of teosinte introgression in archaeological maize," in *Botan. Museum Leaflet Harvard Univ. No. 17* (1956), pp. 101–124; P. C. Mangelsdorf and R. H. Lister, "Archaeological evidence on the evolution of maize in northwestern Mexico," in *Botan. Museum Leaflet Harvard Univ. No. 17* (1956), pp. 151–177.

Can There Be Too Much Research?

With competing demands on scarce resources, more applied research may curtail education and progress.

Fritz Machlup

This article deals with an important question arising from the recent growth of research and development and the loud cheers that have accompanied this growth. Several kinds of research will be touched upon, but my chief subject will be industrial research and development. This four-word phrase will be referred to often, and the use of "IRAD" as a code word for it will save space.

Phenomenal Growth of IRAD

It has been estimated that the expenditures for IRAD in 1930 were less than $120 million; in 1953 they were $3700 million, and in 1956 they were $6500 million. One might make two reservations concerning the legitimacy of measuring the growth of IRAD by dollar outlays: that the data for the earlier years are not reliable and that the value of the dollar has diminished over the period. Yet neither of these considerations can throw any doubt on the order of magnitude of the figures in question.

The figures for recent years include large amounts of public funds spent by industry under government contracts; in 1956 no less than 49 percent came from the Federal Government. In addition there were direct expenditures of the Government for research and development performed by its own agencies ($1400 million) and expenditures for research, basic and applied, in universities and other nonprofit institutions. Some expenditures for *basic* scientific research are included in the figures for IRAD, but this is only a small portion—about 5 percent in 1953—of the activities of industrial organizations. Hence, when we speak of IRAD we mean primarily *applied* research and development, designed to produce new or improved technology—some of it in the form of inventions, patentable or unpatentable; some of it concerned with the application or adaptation of inventions and the acquisition of know-how; but all of it useful in industrial production involving new products, new devices, new processes.

Much of the phenomenal growth of IRAD has been connected with the war and defense effort of the nation, either directly, as in the execution of "crash programs" for the development of weapons and other defense materiel, or indirectly through the transfer of the "research-mindedness" of defense production to industry in general. Some of the increase in IRAD expenditures has probably been connected with the tax laws, especially the combination of high corporate income tax rates (and still higher excess-profits tax rates after the war) with the deductibility of IRAD payrolls from taxable income. In any case, industrial research has become very popular, not only among industrialists but also with the consuming public, as one can infer from the public-relations emphasis upon industrial research. In the main, the new research-mindedness of industry has probably proved profitable as well as productive, and everybody is satisfied that the increase in industrial research has been a splendid thing all around.

The More the Better?

If this past increase has been such a desirable development, should we be content with the level attained or should we press for more? Should we devote an ever-increasing portion of our resources (chiefly human resources) to industrial research, or is there perhaps some limit beyond which we should not go? It is easy to see that an economy might fail to allocate enough of its resources to IRAD. But can there ever be too much? Is not more research and development always better than less?

For most noneconomists the answer looks simple: More IRAD will produce more invention of better products and of better production techniques; this, in turn, will raise our standard of living; hence, we should always encourage industrial research, by allotting more government funds, by further liberalizing the tax laws, by strengthening the patent system, by employing whatever methods seem appropriate. "Let us have more IRAD, the more the better."

This view fails to recognize the existence of an economic problem—that is, a problem of choosing among alternatives. Economics comes in where more of one thing means less of another. To be sure, it would be nice to have more of a good thing, but if this implies that there will be less of something else, one should compare and choose. It is the

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economist's task to analyze what alternatives society will have to forego when it does what seems so desirable to many or to all. The social cost of what *is* done is the value of what *might* be done instead. In technical terms, the social cost of any action is equal to the value of the most valuable alternative opportunity that has to be foregone.

Many highly sophisticated economists will likewise incline to the view that there should be more inventive activity, not because it would be without social cost, but because the social cost is apt to be much smaller than the social benefit from the increased activity. They are convinced that society stands to gain from a shift of resources toward "inventing." By and large, economists in the free world are willing to rely on the price mechanism to guide or steer resources into the most wanted uses. But they recognize that there are certain situations or areas in which market prices and business profits will not adequately reflect the social benefits derived from particular goods or services. The private benefits that can be derived from inventive work are, as a rule, less than the potential social benefits. To express it in the economists' lingo: Since the "external benefits" of inventions—"external" because they accrue to individuals other than their producers and users—are substantial, the "social marginal product" of inventive activity is greater than the "private marginal product"; this implies that without government intervention not enough resources are allocated to the business of inventing, and that the total social product—the flow of real output—could be increased by shifting additional resources to IRAD.

Whence the Manpower

From what sectors of the economy can one withdraw the productive resources that are to be transferred to IRAD? Let us list all conceivable "sectors" that might be raided for manpower and then ask how likely each of them is to give up the human resources wanted for increased IRAD. (There are also IRAD expenditures for resources other than human, but the problems of finding buildings, apparatus, and materials needed for IRAD are not so serious.) "Inventive personnel" may be recruited by getting qualified persons away from (i) involuntary leisure, (ii) voluntary leisure, (iii) the production of security from invasion and revolution (including the production of military goods), (iv) the production of consumers' goods, (v) the production of capital goods, (vi) basic research, or (vii) education.

A shift of qualified persons from "involuntary leisure" to inventive activities would surely be the best of all possibilities, since the diminution of involuntary idleness would be a boon rather than a sacrifice. It would mean that there have been unemployed talents waiting to be used—talented individuals anxious to give up the leisure that had been imposed on them. This possibility, however, must be written off as an illusion if we are engaged in serious economic analysis. "Depression economics," based on the assumption that there are pools of unemployed resources ready to be put to work, has its uses, but only for what has been called an "upside-down economy" (*1*). Economic theory and economic policy for the "right-side-up economy" would be badly vitiated by the assumption that there are ever-ready pools of productive resources that can be drawn upon at any time, to any extent, for any use.

A shift from "voluntary leisure" would be the next best possibility. It would mean that some qualified people are ready, with some inducements, to devote more time to inventive activity, not at the expense of any other productive activity but at the expense of some of their leisure time. These people may be professionals or amateurs. The former are the scientists and engineers already in IRAD and possibly willing to work overtime. This pool of potential resources may be of great importance for the implementation of "crash programs" of research and development in a national emergency. But long-run programs, not directed toward specific goals (like winning a war or an international race for accomplishment of a particular technical feat) but designed for "progress in general," cannot successfully be based on the continuous and continual supply of overtime labor. The other source of volunteer labor—amateur researchers and tinkerers, busy with other jobs during their regular hours but glad to use their free evenings and weekends for inventive activity—can probably be drawn upon regularly. (Mobilization of these "individual inventors" was perhaps one of the achievements of the patent system in times past.) But this is a very limited source of supply, perhaps already fully utilized; in addition, the role of the "evening-and-Sunday inventors" has become quite insignificant in our age of organized research and development. Thus, the possible sacrifice of leisure cannot be counted on to provide the labor for additional inventive activity.

One must assume that society has allocated to national defense the resources that its experts consider indispensable. If the threat of invasion or revolution increases, resources will have to be withdrawn from other uses; if that threat is reduced, resources can be transferred and larger allocations can be made elsewhere. But one cannot reasonably assume that civilian industry, when it wants to increase its IRAD staff, will be able to raid the defense establishment or defense production for large numbers of engineers, even if one could find there the men qualified to do inventive work.

Alternative or Complementary Growth?

Having disposed of—as illusory—the first three hypothetical pools of manpower for additions to the IRAD staff, we may find it expedient to stop a moment for reorientation. The sectors left for consideration are the production of consumers' goods, the production of capital goods, basic research, and education. Let us now combine basic research, education, and applied research and development (including IRAD) into one sector, called "production of knowledge," and examine its relation to the other two. Is it really correct to regard these three sectors of production as alternatives? Since they actually have grown together, should they not rather be considered as complementary? Has not every increase in the production of capital goods helped, rather than hindered, the growth in the production of consumers' goods? Has not every increase in the production of knowledge accelerated, rather than retarded, the growth in the production of both capital goods and consumers' goods? Evidently, here is a conflict in economic interpretation that must be resolved before we can proceed.

Historically, production has increased simultaneously in all three areas; looking back over long periods, one does not find any absolute reduction in the production of consumers' goods when more resources were allocated to the production of capital equipment and of knowledge. Simultaneous increases in all areas have been possible because of the increase in the

total labor force and because of the advance of productivity. As more manpower became available, absolutely larger numbers could be allocated to all lines of endeavor; an increased allocation to one sector did not presuppose an absolute curtailment of others. But in percentage terms the allocation was still a matter of alternatives. And it is in these terms, and in terms of output per head, that the problem of resource allocation in an economy with rising population must be analyzed. Clearly, a relative increase in the allocation of resources to any one line of endeavor implies relative curtailments of others. (In a permissible simplification of the argument, teachers of economics often make the assumption, in the theory of resource allocation, that population and labor force remain constant. This permits them to present in terms of absolute quantities what for a growing population holds only in terms of relatives.)

Even with a constant labor force it is possible for production in all areas to increase if productivity—output per worker—increases. And productivity will almost certainly increase as more capital equipment and more technical knowledge are accumulated. Hence, with the advance of productivity it becomes possible to reduce the allocation of resources to the production of consumers' goods, and to increase the allocation to other areas, without causing any decline in final output. Indeed, this gradual reallocation of resources from consumers' goods production to the accumulation of capital and of knowledge will cause the output of consumers' goods, in the long run, to increase even faster.

This does not contradict the truth about the fundamental "alternativeness" of production of consumers' goods, capital equipment, and knowledge. At any moment of time, the three "departments of production" compete for the available resources, and increases in the allocations to the production of capital and knowledge at a rate faster than the rate of growth of manpower and of productivity will reduce the per capita output of consumers' goods in the near future.

Competition for Scarce Resources

The notion that an increase in the production of capital goods or in the production of knowledge should, if only temporarily, hold back the production of consumers' goods is so contrary to widespread preconceptions that we must not expect it to be easily accepted. Some slightly more thorough elaboration, or even a repetitive reformulation, may therefore be appropriate, or at least forgivable.

An increase in the stock of knowledge may lead to a rise in productivity and thus to increases in the output of consumers' goods and capital goods. Similarly, an increase in the stock of capital goods may raise productivity and thus permit increases in production. This may suggest that the most rapid accumulation of capital goods and knowledge will permit the fastest increase in consumption. But, alas, such accumulation presupposes the availability of resources. If resources are being fully used, increased appropriations for investment in capital and knowledge must imply reduced appropriations to the production of consumers' goods. There is, therefore, a dilemma: The way to increase consumption is first to reduce it. Only by reducing the production of consumers' goods can society transfer resources to the production of capital goods and useful knowledge, and only subsequently can the increased stocks of capital and knowledge raise productivity enough to enable the diminished resources that are allotted to consumers' goods production to bring their output back to the former level and above it.

These fundamental principles are sometimes forgotten, especially in rich economies or in economies with large pools of unemployed resources of some sort; yet they are essential to our understanding of economic development. It is very difficult for an undeveloped economy to advance to higher levels because poor people would starve to death before they could accumulate enough capital equipment and useful knowledge to raise their productivity sufficiently to permit a substantial increase in their consumption. The same principles work also in highly developed countries, though usually by affecting relative rather than absolute magnitudes: Consumption can still increase absolutely, thanks to accumulation from preceding periods, even when productive resources are shifted to the production of equipment and knowledge. What happens there is that a large part of the potential increase in the output of consumers' goods is "seized" when the consumption sector must give up resources to the other sectors. That the expansion in one sector encroaches on the others is sometimes forgotten, with unpleasant consequences. The drive to increase investment and consumption at the same time, and by more than the "inherited" increase in productivity would permit, results in price inflation. Increases in money outlays, bidding for a supply of goods which is not increased in the same proportion, are apt to show up in price increases (or shortages, where prices are not sufficiently increased); thus, the "effective demand" is partially frustrated. In other words, pushing forward more vigorously on one of the three fronts may force an unwanted pullback on one or both of the others. Such a forced retrenchment may have especially harmful consequences in the long run if it occurs in the area of "reproduction of knowledge"—that is, in education.

Increased research and development in order to increase the stock of knowledge is a splendid thing for society; so is increased production of productive equipment, and both are so highly valued because they eventually allow increased consumption. Yet, these three—more knowledge, more equipment, and more consumption—are alternatives in the sense that, even though all three can increase when productivity increases, a greater increase of one must mean, for the time being, smaller increases of the others. At any one moment, an increase in the production of knowledge means less equipment or less consumption than might otherwise be available, or less of both. A choice by society to increase research and teaching implies a choice, though usually unconscious, to have in the next years less productive equipment or less consumption, or less of both, than they might have had. Should a relative cutback of consumption prove impracticable, the choice is between "knowledge" and "equipment."

Replacement and Expansion

As a matter of fact, things are much more complicated than this simple set of alternatives may suggest. Capital equipment is produced partly to maintain the stock and partly to increase it. One might conclude, as the statistician does, that "net investment" is simply the excess of total production of capital goods over depreciation—over the used-up part of the stock. But it is possible to increase the production of one kind of equipment and neglect the replacement of another. For example, one may push the production of hydroelectric and atomic power plants and neglect the maintenance of the highways and of the

roadbeds and rolling stock of the railways. On balance, there might still be "net investment" or "accumulation of capital," and yet the failure to replace transport facilities may one day cause so serious a bottleneck that the total production may fall catastrophically. (In a competitive free-enterprise economy the danger of such an occurrence, in my opinion, is minimal, but it may be very real in a war economy or in a centrally directed economy.)

In an economy with increasing population and labor force, some "net investment," or net increase in capital stock, is needed merely to keep output per head from falling: Tools, machines, buildings are required to equip the additional labor force and maintain the average productivity of labor. Customarily, all new capital equipment above that needed to offset depreciation is called "accumulation" or "net capital formation." Yet, the part of it that merely serves to maintain capital per worker at the level previously attained, and thus does not contribute to an increase in output per head, had better be set apart from "accumulation in a narrower sense"—namely, in the sense of "production that increases capital per worker."

Similar questions and difficulties exist in the analysis of "production of knowledge." Here, too, necessary replacement may be neglected while "new knowledge" is produced, and the concept of "reproduction of knowledge" is highly problematical. The teaching of established knowledge to the young who are to take the places of those who retire or die is clearly replacement, or reproduction. But what about the education and training of the rising generation in an increasing population? If the number of people taught exceeds the number of the skilled that are lost to the labor force through death or retirement, this "volume of teaching" accomplishes more than "reproduction of knowledge" in a strict sense. On the other hand, if the percentage of people that are educated and trained were falling off, "knowledge per head" in the growing society would be reduced and productivity per worker might suffer. Thus, in order to maintain average knowledge and average productivity, it is necessary to educate increasing numbers of young people. Matters are complicated, however, by the possibility that opposite changes may occur in the percentage of people educated and in the level of education attained. Where the former is raised but the latter is lowered, it may be impossible to measure whether "knowledge per head" is maintained, increased, or reduced; but whether it can be measured or not, the possibility of a reduction cannot be denied.

The problem becomes even messier if there are opposite movements in the acquisition of new knowledge, in the dissemination of new knowledge to the few that are immediately concerned, and in the dissemination of established knowledge—education and training—to the rising generation. If resources are shifted from education to IRAD, the accumulation of new technical knowledge may be accelerated at the expense of the dissemination of established general knowledge. It is possible for industry, by providing more attractive job opportunities (for IRAD as well as for other kinds of qualified work), to drain schools of the teachers needed for the instruction of the new generation. No statistical technique is available to indicate whether the "net increase in knowledge" is positive or negative when a high rate of output of new technical knowledge, inclusive of inventions, is accompanied by a decline in the performance of the schools. The time may come when a lack of adequately trained graduates of the schools creates a bottleneck, obstructing not only further progress in the arts but also the maintenance of the general productivity of the people.

As in the formation and reproduction of capital, the problem is one of timing. Pushing IRAD *now,* in order to increase the production of new technical knowledge, may be at the expense of the reproduction of established knowledge and may result in an eventual decrease of general productivity with a forced reduction of IRAD *later,* perhaps even with a net loss in the production of technical knowledge in the long run.

Basic and Applied Research

It has been customary to divide knowledge, teaching, and research into two main categories, one of which is characterized as general, fundamental, liberal, basic; the other, as applied, practical, vocational, technical. The distinction is a useful one, even if blurred in many instances. The difference between basic and applied research happens to be significant for our present inquiry: whether there can be too much research.

We have stated that IRAD competes for the kind of human resources that are required for educating the young. Schoolteaching and applied research are largely alternative occupations; where both are full-time jobs, the qualified college graduate or the young M.A. or Ph.D. will accept either an IRAD job or a teaching job. The instances in which a man in IRAD work also teaches an evening class, or in which a teacher also serves as an industrial consultant, are merely exceptions which confirm the rule that applied research and teaching are alternatives. This is not the case with basic research, which to some extent is a complementary activity of teachers at advanced levels.

The essential complementarity between teaching (especially postgraduate) and basic research has always been recognized by institutions of higher education. The performance of university professors is judged, as a rule, by their research work, and it is from the great research scholars that advanced students have received their most lasting inspirations. The respected teachers in the best universities devote much less than one-half of their time to teaching and much more to basic research. By and large, the more research they do, the better they will be as teachers. Of course, teaching and research cannot be complementary where heavy teaching loads make it impossible for college teachers to carry on any significant research. Perhaps, if the amount of teaching is measured by the hours of classroom work, all research must be considered an alternative to teaching; only when the amount of teaching is measured by the results achieved—in terms of the intellectual capacities developed—will basic research be recognized as complementary to teaching on the highest levels.

The combined activity of teaching and basic research is not necessarily confined to the classrooms and laboratories of colleges and universities. Also outside academic institutions, in research organizations of all kinds, including the rare but outstanding basic-research teams maintained by industry, basic research may have teaching as a by-product when young research assistants, attached to a great scientist, can, under his guidance, informally continue their education no less effectively than on a campus.

The social benefits of basic research are invaluable, and its social cost is probably not too high. For apparently only a relatively small number of people can qualify as workers in basic research, and, hence, the promotion of basic research will not encroach heavily on other pursuits. If those who do basic research are

engaged in higher education, their usefulness as teachers may be increased, not diminished. And when the funds for basic research go to institutions of higher education, such outlays stimulate the employment not only of better but also of *more* academic teachers by enabling universities to meet more successfully the attractive salaries industry offers to qualified scholars in administrative posts and IRAD positions. In other words, increased public outlays for basic research are not likely to encroach on education. On the contrary, they may aid education by allowing universities to hold on to scholars who might otherwise be lured into industry, by allowing scholars to improve their qualifications as teachers, and by attracting more qualified young people into careers of scholarship. On these grounds one may say that there is little danger of there being "too much basic research."

IRAD and Adequate Education

However, IRAD and education—the acquisition of new applied knowledge and the dissemination of established basic knowledge—may be in serious competition with each other, especially if the teaching profession serves as a recruitment pool for IRAD personnel and if IRAD job opportunities attract promising college graduates away from school-teaching.

Since the production and reproduction of knowledge nowadays is almost completely a government concern, an imbalance cannot be corrected by free enterprise. Schools are maintained chiefly by local government with the help of state government; more than 50 percent of research and development is financed directly by the central government; and a substantial part of industry-financed IRAD is indirectly paid for by the government when it allows the IRAD payrolls to be deducted from the corporations' taxable incomes. Even the part of IRAD that is not paid for by the Government is—according to many authorities—largely dependent on incentives held out by the governmental system of patent protection for inventions. Thus, whatever imbalance develops within the area of the production and reproduction of knowledge, as well as between the production of knowledge and the production of investment goods and consumers' goods, is not to be blamed on the competitive economic order but on the inadequacies of governmental planning.

These are not just academic speculations but very real problems of urgent concern to our democratic process. The high taxes needed to finance education and research cannot but impinge on the production of other things, and industry feels the pinch not a little (as does every taxpayer). On the other hand, the neglect of education is becoming increasingly notorious and is to a large extent attributable to the inflationary increases of wages and salaries in industry, which have made the financial rewards to teachers and scholars inadequate for the maintenance of the required supply.

It is contended, in some quarters, that technical improvements in teaching will make it possible for more students to be taught by fewer teachers. Experiments in the use of television methods of teaching are receiving conflicting evaluations. Some find television classes most promising, others are more than critical. Even without quantitative evidence it seems safe to hold that a good television lecture by an excellent teacher will be more effective than a poor classroom performance by an inferior teacher. It seems equally safe, however, to hold that passive observation of a television screen is a very imperfect substitute for active student participation in discussion in small groups. Perhaps the eventual introduction of mass-production methods in high-school and college instruction is inevitable; and perhaps, when this comes to pass, the demand for manpower for IRAD will encroach less on the supply of qualified teachers than it seems to do at present and may do even more seriously in the next few years.

Rational Resource Allocation

With the pressure of competing demands on the productive resources of the nation that exists today, the problem of allocation of resources deserves more thought than it has been given. According to their special interests, or often out of sheer enthusiasm, different groups try to promote increased outlays for capital investment, increased expenditures for education, increased disbursements for IRAD, and increased consumer spending, all at once—not just in times of depression (when it would make sense) but all the time. Of course, every one of these increases would be fine to have, but since they compete with one another we should first make up our collective minds regarding the comparative advantages. No matter whether an increase in industrial research is financed by the Government or by private industry (under the patent system or with some other stimulus), the decision to increase inventive activities is fully rational only when it seems likely that productivity can be raised faster and maintained more securely through more new technical knowledge than through more capital equipment, more basic research, or more education. If the total amount of productive resources that can be withheld from the production of consumers' goods is limited (as it must be), how much should be allocated to the production of capital goods, how much to the reproduction of established knowledge, how much to the acquisition of new basic knowledge, and how much to the production of increased technical knowledge? This is a matter for economic judgment, tempered by important political and moral considerations. It would surely be foolish to allot to IRAD *all* the resources that can be spared from the consumption sector; it would be stupid to allot *none* of the available resources to IRAD. Even very far within these extremes there may be too much promotion or too little promotion of IRAD.

It has become fashionable among students of economic growth and development to acclaim technological progress as the number-one factor in the process. This may be perfectly justified, but it does not imply that IRAD should be singled out as the most important of all pursuits. Some of those who stress IRAD in order to reduce the emphasis upon capital investment forget that the increase in the stock of capital goods may have been a necessary condition of all technological development. Others who play up IRAD at the expense of liberal education and of basic research forget the dependence of technological research upon advances in basic knowledge and upon an adequate supply of highly educated people. If one puts education, training, research, and development all into one category and sets it against investment in industrial plant and equipment, then one might possibly find evidence for the contention that—in some countries and over some periods of time—the investment in knowledge has contributed more per dollar to the increase in labor productivity than the investment in physical industrial facilities. The

bracketing of research with education is necessary for this statement to be tenable; for, among other things, the researchers and developers must have been previously educated and trained, and the utilization of new technical knowledge often requires degrees of dissemination and comprehension that cannot be attained without broad and general education.

If it should be possible to find statistical criteria for the identification of the specific contributions which "investment in knowledge" and investment in physical facilities have made to the increase in productivity, and thereby to obtain evidence for claiming "major credit" for the former, one would have to guard against the mistakes of regarding these findings as pertinent for other places, other times, and other allocations of resources. Particularly one would have to guard against the fallacy of confusing "total utility" and "average utility" with "incremental (marginal) utility." It is perfectly possible for technological research to deserve first prize in the distribution of merits for economic growth and, nevertheless, not to deserve first claim on additional resources.

Lest these remarks be understood as an attack on IRAD, or as a plea for drastic curtailments of IRAD expenditures, be it noted that such has not been my intention. I have intended to show that there *can* be too much IRAD work, not that there *has* been too much of it. Whether the present rate of IRAD expenditures is too high, too low, or just right, I do not know—though I am impressed with the present plight of education and cannot help looking askance at any so clearly identified rival bidder for potential teachers. In any case, a warning is in order against the position of the IRAD enthusiasts who champion the idea of "the more the better."

Note

1. This colorful expression was used by Abba P. Lerner [*Economics of Employment* (1951), pp. 141–150]. An "upside-down economy" is characterized by unemployment of all the productive resources that would be needed to produce increased amounts of goods and services. "Topsy-turvy economics is appropriate for an upside-down economy" (*ibid.*, p. 142). Such an economy is upside down because it would not be benefited by the things which contribute to the welfare of a normal economy—namely, economy, efficiency, and thrift—but, rather, would be benefited by their opposites—wastefulness, inefficiency, and prodigality (*ibid.*, p. 146). The prescription for upside-down economies is to print money and spend it. But when this prescription cannot lift the economy beyond a certain level of employment and activity, this level should be regarded as normal, and topsy-turvy economics should be shelved in favor of "ordinary economics," "concerned with the economical use" of scarce resources.

Literature in a Technological Age

Attitudes and values involved in a possible symbiosis between arts and science students are discussed.

T. R. Henn

This article is, of necessity, concerned with some problems in English education; but my experience of American and Canadian universities suggests that the problems may not be different there. For I have seen Plato issued as "mandatory" reading for the first-year students at the Royal Military Training College of Canada, and Sir Richard Livingstone was invited to lecture on that writer at Massachusetts Institute of Technology. I have listened to discussions of poetry at West Point, and by physicists and engineers at a dozen universities, and was struck in every instance by the eagerness, tact, good taste, and intolerance of nonsense that was apparent everywhere. Indeed, many of my best students of English have been trained in other disciplines—mathematics and natural sciences as well as classics or modern languages—and there is much to be said for these preludes to literary criticism.

But we are told that the gap between sciences and arts is steadily widening; that in a few years' time our society will be predominantly technological, and that this is because the whole cultural pattern of the world is changing. The study of literature and particularly of poetry thus becomes an interesting, perhaps pleasant, but wholly useless, anomaly, belonging (as Peacock saw it a hundred and fifty years ago) to a heroic age, and out of place in this age of iron. Our educators feel, vaguely, that this negation is "a bad thing." Here and in North America there have been countless experiments in "integrated courses." I have seen large classes of engineering students sprayed, as it were, with the warm Eau de Cologne of "Eng. Lit.," or dragged unwillingly through courses in "creative writing," their mentors hoping, rather despondently, that some of them would acquire a veneer of "culture." (Should not we still reach for our revolvers at that word?) We must examine the complaints a little more closely.

There is, in the first place, a fairly steady outcry against the relative illiteracy of many advanced students of science. Often this comes in the form of criticism of the shapelessness, inaccurate English, and lack of formal control in scientific writing, particularly at the postgraduate stage, with a consequent waste of time by those who direct such studies. Parallel to this, yet of quite another order, is the complaint, both from teachers and employers of scientists, of the lack of what Shelley called "the creative imagination." By that he meant, I think, no more than the ability of the mind that has been trained to think *synthetically*; to make, from time to time, "leaps in the dark"; to meditate profoundly on resemblances and analogies between things; and so to lead the way to creative thinking, which is apt—so I am told—to atrophy under the sheer weight of factual knowledge that the student of any of the great sciences must master today.

There are other complaints. Great in-

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dustrial firms appear to find that, while the supply of *competent* technologists is adequate for their purposes, the supply of men for the very top posts—men who know enough science to direct research, yet whose concern is mainly with wider issues and problems of the highest magnitude—is relatively poor. Many of these firms find it profitable to select arts men —preferably, and strangely, classicists—and train them for such posts. A world-famous electrical firm has just taken seven men with first-class degrees in classics and is converting them, by an intensive three-year course, into physicists and mathematicians. Cambridge University has before it a plan for a one-year course (as a tripos, part II) in physics (*1*) of such a nature that it could be taken by a man (necessarily of high intellectual caliber) who had spent the previous two years in one of the arts disciplines.

But the roots of the matter lie much deeper than this. The student who wishes to read science or mathematics at a British university today has, virtually, to spend his last three years at school—say, from the age of 16, more or less, to about 19—working intensively to obtain admission in his chosen subjects. He is confronted, by university requirements, with such a mass of knowledge that this specialization appears inevitable, though many university teachers deplore and lament it. For his ordinary level General Certificate of Education he will have taken five subjects, including one or two languages, to qualify him for university matriculation; but he will have little or no opportunity to keep up, and strengthen, his Latin, French, German, and English. Yet he has been faced, at the age of 15½ or 16, with the necessity for choosing one of the two roads, leading either to arts or to science; and here it is worth remarking that, while the school child who has chosen the science road can, and sometimes does, switch effectively to arts after a year or so, the reverse does not hold good. It is true, indeed, that one or two Cambridge colleges do offer entrance scholarships in classics for prospective medical students, and while such men often do brilliantly in the long run, they are faced with the need to spend one or two years in gaining the necessary preliminary qualifications in physics, chemistry, biology, zoology, before they can enter the university. Something of the sort applies to the new scholarships founded by Imperial Chemical Industries to enable the arts students to "convert" to sciences.

The schoolboy, then, is usually faced with the need for making this early choice. We may glance at the reasons on which his choice is based. Often it is a romantic one, disguised in various ways. The scientist is the supremely romantic figure of the present age, and much of the schoolboy's reading fosters this view. He is the controller of "push-button" power, always a satisfying fantasy. Science at his particular school may have a "snob-value" (these emotional factors are often significant), and the "best" people are going on that side. (Forty years ago the reverse was usually true.) The boy may even argue along lines somewhat similar to these:

"The scientist, and the scientist alone, is pursuing "truth" [that is, naively, "verifiable facts"]; he [and he alone] will find, preferably at an early stage, the *science*—not the art—of living."

The boy is profoundly impressed by the national demand for the scientist, by the scientist's high value in the labor markets, because of his scientific attainments. Therefore, in selecting science, he is in a sense one of the "chosen" who will help to diminish the disparity in numbers between the technologists of his own country and those of others.

The *values* which he holds, consciously or potentially, might be expressed thus: The two major ends to modern life are (i) a higher standard of living, (ii) more leisure. Both ends are subserved by the scientist-technologist, and by him alone. Therefore the scientist-technologist is the most important figure in the modern world. We may note that the boy appears to be encouraged in these views at every turn, by advertisements and by the daily press, and by those most important formative influences, the comic papers.

If this view is substantially correct, there may be certain corollaries which we might tentatively summarize as follows: (i) All "truth" is or should be susceptible to scientific evaluation. (It is worth noting that the schoolboy is seldom forced to clarify in his mind the nature of this term.) (ii) All "spiritual" values, which are not susceptible to such evaluation, are at best peripheral, at worst "false." (iii) All "art," being concerned with subjective values is—I use a selection of epithets—"effeminate," "sissy," "escapist," "unreal," "self-deluding." (We shall not get quite so far, as yet, as "the opium of the suburbs.")

Along with these corollaries we may find a tendency to rationalize an aversion to literature and art on the pretext that "there is no time for it"; that it is not worth "wasting time and trouble over" (this is encouraged by "potted" books, digests, strip cartoons, and so forth, which all suggest that literary processes can be short-circuited). And perhaps the compartmenting of college courses, which allows men to study *and forget* a particular subject, militates against the acquisition of reading habits that are likely to be carried into later life. Similarly, the enormous amount of typed matter—in business, politics, or warfare —which the duplicating machine has made possible is probably another factor which makes us all inclined to minimize the importance of the printed word, and to reject meditation upon it.

Minimum "Arts" Requirements for the Scientist

Before we go into the deeper questions of attitudes and values, we must consider the minimum requirements in "arts" for the scientist or technologist. These we might tentatively suggest to be as follows: (i) the ability to describe, in clear and correct English, *any* scientific process or event; (ii) the ability to construct, logically and with complete clarity, a scientific statement or paper of any length, using the normal resources of language to ensure efficiency of communication; (iii) the ability to present verbally, with clarity, cogency, and brevity, statements which aim to *persuade*; (iv) the ability to handle, in correspondence, not only matters which demand statements of "impersonal" business negotiations but also those involving, both directly and obliquely, complex human relationships; (v) the ability to draft agreements, contracts, concordats, and so forth, with both factual accuracy and sufficient constructive imagination to foresee (to use Aristotelian terms) "what might happen according to the laws of probability or necessity." (A simple instance is the work of a legal draftsman, who must envisage or imagine all the possible contingencies arising out of a set of provisions.)

In addition, we should probably demand a reasonable ability to read French —at the lowest level, for its scientific literature, or, more moderately, because we may hold that no one can be considered civilized without that knowledge. To this we should add a working or dictionary knowledge of German and of Russian, without which an enormous mass of scientific knowledge is sealed away. Ideally we should add Latin and Greek, to enlighten, and perhaps enliven, our scientists' vocabularies.

And if we accept some such objectives as these as desirable, how are we to achieve them?

Roads to Good Writing

At this point I think we must be ruthlessly dogmatic. There is no way to learn to write except by (i) reading good English prose of as many varieties as possible and (ii) practicing incessantly. Further, the practice in writing must begin early and must be built up and encouraged by individual correction of the thing written. No short cuts are possible, no lecture courses or mass classes in composition, however admirably planned, can ever replace individual training in prose writing, and in the clarity of thought that must accompany it. It is not difficult to lay down the qualities of an ideal prose in a technological society; they would probably be, by common agreement, roughly as follows: (i) clarity; (ii) adequacy (a full vocabulary); (iii) unity (the organization of the thought, the internal structure of sentence, relationship of sentence to paragraph, of paragraphs to the whole); (iv) *organic* quality (suitability of tone to intention); (v) avoidance of monotony (ability to interest, and consequent increased efficiency of communication); (vi) rhythm, supporting and enforcing meaning.

We should, of course, assume a full understanding of all the uses of punctuation, including its more subtle powers of presenting nuances of meaning. With regard to our scientific papers, it seems to me that confusion most often arises through a failure to recognize the basic *structure* of any piece of writing of this nature. For example, many of the theses that I have seen would have been better if the writers had in mind even a simple mnemonic such as this:

*O*bject: What exactly am I trying to do—prove, state, expound?
*R*eferences to previous work already done on the subject and up to the point at which the new work is being continued or projected.
*I*nformation about the facts now under enquiry.
*D*escription of those facts prior to the analysis of them.
*A*nalysis of the facts.
*S*ynthesis and deductions.
*C*onclusions in relation to the
*O*bject of the paper.

There is in this a suggestion of a circular structure, the whole being summed up under the mnemonic ORIDASCO.

Words and Meaning

I have suggested that there is no short and easy road, no substitute for practice and individual correction. But I believe that much might be done, concurrently, to arouse an interest in language as an instrument by showing, quite simply and, where possible, by means of scientific imagery, the uses and limitations of words as signals. Much of this will seem elementary; but too often it seems that the elements have not been given to students in the right way at the right point in their development. We might, for example, stress the difference between technical, defining language and emotive language, and the vast area that is common to both kinds, perhaps starting with a consideration of such words as *absolute, neutral, temper, sublimate*. We could indicate the multiple potential meanings of words by means of electrical or electronic images; the selection of meaning by qualification, position, stress, pitch, tone, accent; the instances in which several possible meanings are allowed to exist simultaneously, as often in poetry; the place of tradition and usage in modifying and establishing meaning.

And to do this we shall require sheets of carefully selected examples, starting always with prose statements which relate to one of the students' intimate spheres of scientific interest. (One source of failure is, I think, the habit of starting students on relatively complicated philosophic or literary examples, merely because these are traditional.)

It is not impossible to use mathematical formulas to show the determination of meaning in relation to the selector-mechanism of the mind, and the place of rhythm in this selection, and this would lead naturally to elementary semantics and phonetics. Thence we could consider the nature and functions of imagery, perhaps in terms of a thermionic valve (*2*); the fixing of a point of meaning in terms of coordinates (*3*); the possibility of penumbral meaning (*4*). And this would provide some valuable groundwork for a later—much later—discussion of the philosophy of poetic statement.

"Nonprofessional" English Teachers

At this point we may face up to certain difficulties. I have no doubt whatever that in many instances there are in the background strong emotional factors which are perpetually at work to widen the gap between the scientist and the arts man. One of them is the question of *beliefs*, at which I have hinted earlier. It is probable that the pattern is firmly established at 17 or so (much depends, of course, on the family background), and it is worse than useless to confront it directly. The intervention of the "professional" teacher of English at this stage often does far more harm than good. He is suspect, belonging to an alien world, claiming a *mystique* which is (in the eyes of the student) probably bogus, probably effeminate, and expounded by those who have no effective contact with the scientists' values and problems. (In certain societies he may be seen as a financial failure as well.) The English teacher is too often aware of a veiled or overt hostility, and this may lead, on his part, to the fatal assumption of a superior attitude. I am inclined to think that the teaching of English at this stage should be done wherever possible by the science teachers themselves. They and they alone can begin without being suspect. And if the science teacher himself can move naturally and gracefully among other arts (as many of the greatest do, finding analogies and examples from architecture, painting, history) in the course of their everyday work, it is surprising how readily and fully the students respond.

The Human Situation

At some point the science student may inquire, very properly: "I can now write correct and vigorous and clear English. I know enough to avoid emotive words, false analogies, disconnected thought. I can order and control my thought, speech, and writing. Why, then, do you urge me to read literature of any kind, and particularly poetry? I have no time for it, anyway; it is all I can do to master a part of the ever-widening field of my chosen science. All these other things—however desirable in a leisured age—are out of place in this. I except, of course, music, for I recognize its mathematical and scientific basis. I can enjoy, occasionally, an exhibition of paintings, and anyway it doesn't make demands on me, as books do."

These are serious and valid questions, and we must confront them. In the first place, the problem of time is a very real one. It is true that the excuse of "no time" is often, among all students, a convenient rationalization; equally, it is true that an enormous amount can and should be read in odd moments, by anyone who has acquired civilized reading

habits. If there are books readily available, as part of the normal household necessities, and if there is a desire to read, the time will be found somehow, in spite of the commercial interest in presenting new forms of simplified and compressed literature.

To the second question we should, I suppose, reply in some such terms as these:

"Whatever your studies, whatever your standing as a scientist, you are committed at every stage to the human situation, and to the relationships on which it depends. This is true of every social unit, from the family to the councils of nations, and you cannot escape it. And these relationships depend, in turn, on your own sense of values, which (whatever your 'philosophy') you must shape and consider throughout this life, and particularly through 'that toil of growing up.'

"The art of living can never become a 'science.' Even on the lowest terms of the human situation this is a truism. A 'universal psychology' is a contradiction in terms. It is futile to attempt the delegation of responsibility in the psychologist's consulting room. Nor is there any short-circuiting of the natural process that is possible. What *is* available is the vast storehouse of human knowledge, which is yours for the asking, *and* for the effort that you must put into every skill or experience that you have to master. This literature is, first and foremost, the study of the human being and the human situation. Only if you master what it has to give, reading selectively and critically, can you provide yourself with the 'armor against fate' which is essential to the individual in all civilized communities. Only if you possess a sense of history can you control political and social forces. Only if your imagination is trained can you perceive in the experience of the past the seeds of the future and of the world to which you are committed."

Something like this we should say, slowly and no doubt less heavily, but making the approach always from the point of psychology and sociology, and avoiding carefully any suggestion (at this stage) of metaphysical or esthetic content. It would be important to stress the nature of "experience," the balance between the physical and the mental, the need to recreate, imaginatively and historically, the setting of a work, if we are to consider it successfully as a potential fund of experience. A reasonable example might be found in the approach to Shakespeare, who is too often (I am convinced) utterly spoilt at school, because of unintelligent teaching, and against whose work the strongest emotional reactions are often set up. It is possible (and the experiment has been tried in Cambridge) to begin a fresh appraisal, first by sketching in the background of "scientific" beliefs (astronomy, astrology, physiology, psychology, chemistry, physics, alchemy) of his audience and then by examining, in minute detail, carefully selected individual scenes which can be shown (by comparatively small "transpositions") to involve problems of perpetual relevance to the human situation. Such might be: the study of progressive madness through an obsessional neurosis in *King Lear* (the whole play being superb material for the most pressing sociological problem of our time); the values of chastity as debated in certain scenes of *Measure for Measure*; the problem of romantic love and its rejection in *Troilus and Cressida*. It is not always possible to treat works of literature thus, but it looks as if drama in general can (perhaps because of its relative compression) be used to excite that kind of interest which cannot be immediately engaged in longer works.

In an intermediate term between consideration of the novel and of the drama as studies in human relationships, we might lead on to the study of these relationships in correspondence and in speech. For one paradoxical aspect of a scientific and technological age is the enormous power of words, for good and evil, in letters, speeches, diplomacy; the endless difficulties that arise from the misunderstanding of words; the ever-increasing need to learn to criticize dispassionately the power and limitations of words. At all levels civilized man is confronted with the certainty of this need to understand his fellows; almost daily he is confronted with examples, in business and in politics, of the manner in which words can give rise to false emphasis and distortion of thought and emotion. And the greater the scale of intricate cooperation required (as between allies in wartime, or in the business ramifications of great enterprises), the more carefully the exact function of language must be considered, with reflection, too, on the immense advantages enjoyed by those who can order words with fluency and vigor, at conferences and such like, for the purposes of persuasion. Our scientist should thus be confronted with examples —always numerous—of the problems of refracted and distorted fact, of conflicting evidence, of biassed reporting, which are all capable of showing him, positively or negatively, the need for individual judgment.

Poetry

The problem of poetry is far more difficult. Here again I believe that a strong emotional reaction has often been built up against it in schools. There seem to be various reasons for this. As always, the home background is involved; often the attitude is one of mockery, substantiated by the tendency, in a coeducational school, for girls to "take to" poetry more readily than boys. This reinforces the suggestion both of effeminacy and emotionalism, as well as the certainty that poetry is dealing with "values" which, at first sight, are so indeterminate as to be unworthy of a scientist's consideration. Nor do the schools help a great deal. The natural "instinct for harmony and rhythm" is readily vitiated by the imposition, often at the critical age of puberty, of poetry which cannot possibly be brought into any kind of alignment with the reader's real or imagined experience. (Perhaps all poetry that deals with love and death is in this category.)

If we could ensure that our scientists had been introduced to literature through the idea of language as *signals*, the transition to the idea of poetry as a highly specialized form of signals would not be too difficult. We could proceed from the idea of rhythm and the phonetic aspects to problems of statement, first through the consideration of meaning as problems of energy and static or dynamic charges, thence to the nature of imagery. It could be made plain that poetry is a method of making statements that can be made by no other means, and with a series of references of almost limitless complexity. Here, again, it should be possible to start with poetry based on, or related to, scientific terminology; examples from Shakespeare, Donne, Shelley, Bridges immediately start up into the mind.

If we can once establish the claims of poetry as a specialized method of statement, and as such entitled to respect, it seems to me that continuing interest in it should properly be left to grow, or flag, or wither, of its own accord. In any event we cannot hope that the percentage of confirmed readers of poetry should, among scientists, exceed that in any educated community. Its value in stimulat-

ing the "creative imagination" would, of course, vary enormously and could never be measured. But given the conditions and the approach, there would, I believe, be no doubt about its effect. For in that dark saying of Shelley's, "Poetry administers to the effect by acting upon the cause," there are latent innumerable possibilities of the development of the human mind (perhaps by infection), some realization of the virtues of humility, and a sense of the uncertainties latent in the most advanced speculations.

I believe that the "values" that will emerge from literature are, on the whole, best left to grow, through slight but wise guidance, from the thing read, once the desire to read has been aroused and maintained; that more harm than good is done by assuming the attitude that "you *ought* to read so-and-so." The dichotomy is there—the dichotomy that started at the end of the 17th century and has been growing steadily ever since. At the roots of it there is both an emotional antipathy (often a willful misunderstanding) and a tendency to rely upon the apparent fact rather than upon its more profound implications.

Perhaps it is too much to hope for what Oppenheimer calls "the happy symbiosis of science and the general culture of an age." We could, I believe, go far toward improving the present position. And among the most important things that should be done is to foster, by all possible means, the associations of the scientist with the arts man—informally and constantly, with unobtrusive encouragement of the free exchange of ideas. For this we must teach the arts man two things: to rid himself of the frequent defensive snobbishness (not uncommon on university staffs as well as among the students) and to acquire at least the basic vocabulary of the scientist, so that he may speak with him in the gate. For this is perhaps the crux of the matter: whereas the scientist knows, or thinks that he knows, the technical vocabulary of, let us say, the esthetician or the literary critic, the arts man will, unless he takes the trouble to master the minimum technical vocabulary of the scientist, find himself confronted with an impregnable barrier, which is easily converted by the less intelligent scientists into something resembling a *mystique*. One difficulty, of course, lies in the sheer physical means of providing this contact; the growth of the specialized institutions on either side of the fence is steadily decreasing the possibility of undergraduate intercourse on these lines, which still obtains, to a greater or lesser extent, in the colleges of the older British universities.

For it is the growth of the whole man that both sides are seeking, and in that growth, civilized intercourse between students—the free and informal exchange of ideas—is at least as important as any formal instruction that can be given in the classroom. If, in addition, we can insure that in every university there are a few teachers of stature, whether in arts or sciences, who can in their teaching move with some measure of ease from one side to the other and who can create the current sympathy which is essential to understanding, then we shall have done much. Is it a dream to think of a university in which the arts teachers will have studied at least the history of science, and in which all teachers of science will be equipped to teach English as an integral part of their work?

References and Notes

1. See the proposals of the "Principles of science" tripos, as published and discussed (but not yet approved by the university) in the Cambridge University *Reporter* during 1957.
2. I have suggested some of these in a little book called *The Apple and the Spectroscope*. The working of an image can be suggested by a valve, in which a current passes from cathode to anode, through a grid, which selects and filters the particles of meaning that pass over to the object from the image, as in "My love's like a red, red rose."
3. For example, changing meanings of words in relation to civilizations, manners, and sociological problems.
4. This would be perhaps in terms of optics—the graduations of shadow on the edge of meaning.

News of Science

Evolution of the Organization of the Federal Government for Scientific Activities: 1947 to the Present

Major Developments Since 1947

In the years since 1947, a number of significant changes have occurred in the organization of the Federal Government for scientific activities. New agencies with important scientific responsibilities have appeared. Several existing agencies have undergone reorganization, with the step-by-step evolution of organization for research and development in the military departments being of considerable importance. During this period federal scientific programs have burgeoned in size and diversity.

Atomic Energy Commission

The Atomic Energy Commission is exceeded only by the Department of Defense in the magnitude of its scientific activities. The war-born program of nuclear research and production was transferred from military to civilian control in January 1947, but it was more than a year later before the Manhattan Engineer District turned over the last of its contracts to the Atomic Energy Commission. The commission inherited from its predecessor a mode of operation which it continued and further developed. Most of its operations, including research and development, are performed under contract with industrial concerns, academic institutions, and other nonprofit organizations. An important but not large segment of research activity is carried out for the commission in the laboratories of other federal government agencies.

The commission conducts approximately two-thirds of its total research and development program in government-owned facilities operated under contract by industrial and institutional contractors. Some of these, like the Oak Ridge National Laboratory, the Los Alamos Scientific Laboratory, and the Argonne National Laboratory, had their beginnings in the Manhattan Project era. Others, such as the Ames Laboratory, Bettis Plant, and the Brookhaven National Laboratory, have been established since 1947.

In its early years, the commission managed its research and development program through five divisions: production, research and development, engineering, military application, and biology and medicine. In 1949 the Atomic Energy Commission placed the division of engineering within a new division of reactor

development. The division of research continued to have cognizance over research reactors and was authorized to participate in advanced reactor work and supporting research. To coordinate the research aspects of the work carried on in its several divisions, the commission relied mainly on several program committees.

The next major change in the commission's organization which had a bearing on the management of its research and development program occurred in 1954 with the appointment of an assistant general manager for research and development. This action served to raise research and development to a level earlier accorded manufacturing operations by the creation of an assistant general manager for manufacturing.

An important feature of the commission's policy-formulating machinery has been the presence of scientists in key roles. From the beginning the General Advisory Committee has been composed almost exclusively of scientists, and there has been at least one distinguished scientist on the commission itself since its establishment.

In its relations with the military departments, the commission's principal mechanism for day-to-day coordination has been the close working relations maintained between the division of military application and the Armed Forces Special Weapons Project. At the policy level, the Military Liaison Committee serves as the major mechanism for mutual interchange of advice and information between the Department of Defense and the commission. The development of reactors for military use in propulsion and electrical power generation is programmed and coordinated by the director of reactor development of the Atomic Energy Commission. His staff includes military officers who participate in the planning and execution of the military component of the reactor program.

Department of Defense

A series of major changes have taken place in the organization for military research and development since 1947 and, indeed, the organizational situation in each of the military departments is still in flux.

After World War II, the Office of Scientific Research and Development, which had been responsible for a major share of the research and development conducted for the military services during the war, began disbanding. To fill the remaining void, the Secretary of War and the Secretary of the Navy in June 1946, established the Joint Research and Development Board composed of two representatives of each department and a chairman, Vannevar Bush. The board, and the committees through which much of its work was done, represented an interim arrangement for the study of military research and development programs and for reaching agreement between the two departments on common policies, allocation of responsibility for projects in which both were interested, and joint use of facilities. The National Security Act of 1947, which established the Office of the Secretary of Defense and the Department of the Air Force, provided stronger machinery for the coordination of military strength and development programs.

Secretary of Defense. The Secretary of Defense was given broad responsibilities for effecting the unification of the activities of the three military departments. Specifically, he was to establish general policies for, and to exercise general direction, authority, and control over, the national military establishment, and to eliminate unnecessary duplication in a number of fields, including research. [*Note.* The Department of Defense Reorganization Act of 1958 revised the policy declaration of the National Security Act of 1947 to make it clear that the three military departments are under the control of the Secretary of Defense.]

Research and Development Board. To advise and assist him in this, the statute established a Research and Development Board, which reported to the Secretary of Defense. The board consisted of two representatives of each military department and a civilian chairman appointed by the Secretary of Defense. The board's mission included the preparation of an integrated military research and development program, rendering advice on trends in scientific research of relevance to national defense, and recommending measures of interservice coordination and allocation of responsibilities.

The board was assisted by a staff of several hundred military and civilian personnel, whose efforts were supplemented by more than 2000 consultants. The board also created a network of committees and panels. The committees, ordinarily composed of representatives of the three military departments, were largely organized in terms of military programs and problem areas. Most of the panels, which were generally composed of scientists from outside the government, rendered advice on the work undertaken in the major scientific disciplines. The board's staff performed a number of studies of the military research and development programs, organization, budget, and related subjects. The committees and panels reviewed scientific programs and made recommendations as to adequacy and promise in these programs. Acting on the basis of the findings of its staff and the recommendations of its committees, the board reviewed and passed on major programs, made recommendations on the research and development budget to the Secretary of Defense, and concerned itself with various interservice problems such as the assignment of responsibilities, the common use of facilities, and the recruitment of scientific manpower.

The board also developed a system for classifying the research and development effort into categories and programs, and for relating these to the operational needs of the military services. It requested each department to report on the progress of its research and development work in accordance with a standard reporting system, and authorized a unified technical information service administered by the Air Force.

In the first years of unification, the board performed a particularly useful function in providing a forum for the reconciliation of the diverse viewpoints of the three services, and for the exchange of information on activities of common concern. [*Note.* As a result of a number of studies of the organization of the Department of Defense, many changes were effected by the Department of Defense Reorganization Act of 1958. In the areas of research and development, the major change was the establishment of the position of director of defense research and engineering. As outlined by the President, the director will have three functions: first, to be the principal adviser to the Secretary of Defense on scientific and technical matters; second, to supervise all research and engineering activities in the Department of Defense, including those of the Advanced Research Projects Agency and of the Office of the Director of Guided Missiles; and, third, to direct research and engineering activities that require centralized management. Further, it will be his responsibility to plan research and development to meet the requirements of our national military objectives instead of the more limited requirements of each of the military services. This position has not yet been filled.]

Assistant to the Secretary of Defense (Atomic Energy)

Another official in the office of the Secretary of Defense with responsibility for research and development matters is the Assistant to the Secretary of Defense (Atomic Energy). The incumbent of this position also serves as chairman of the Military Liaison Committee, which is the focal point for policy liaison between the Atomic Energy Commission and the Department of Defense. He is responsible for advising the Secretary of Defense; formulating plans, policies, and programs; and representing the department on atomic energy matters.

Other Organizational Developments

The weapons systems evaluation group, responsible to the Assistant Secretary of Defense (Research and Development), was established in 1948. It provides the assistant secretary and the joint chiefs of staff with analyses and evaluations of the comparative effectiveness and costs of present and future weapon systems, and of their influence upon strategy, tactics, and organization. The group, which must be intimately aware of data gathered by the intelligence agencies and of strategic plans, as well as the latest technical developments, has the function of bringing scientific potentialities into a productive relationship with operational needs. In 1955, in response to a recommendation of the second Hoover Commission, the department transferred this activity to contract operation.

Also reporting to the Assistant Secretary of Defense (Research and Development) and to each chief of staff is the Armed Forces Special Weapons Project, established in 1946. This group provides technical, logistic, and training support for atomic weapons to the military departments, and maintains liaison between the Atomic Energy Commission and the Armed Forces in research and development on atomic weapons in areas not covered by the military liaison committee.

Contractor-Operated Research Centers

Each of the three military departments has made extensive use, since 1947, of an organizational device first employed by the Office of Scientific Research and Development during World War II, the contractor-operated research center, usually in facilities which the government owns.

While these centers vary widely in the nature of their management control and the scope of their mission, they all have one thing in common—a primary contractual relationship with one or more of the military departments. This new and steadily growing institutional arrangement has been particularly well suited to research in broad problem areas associated with weapons systems development. Each military department has also used such centers for the conduct of operations research.

For example, in 1949 the Army established the Operations Research Office, managed by the Johns Hopkins University; the Navy utilized the OSRD-born Operations Evaluation Group, operated by contract with the Massachusetts Institute of Technology; and the Air Force activity encouraged and financed the creation of the RAND Corporation, an independent research group with a broad range of research interests.

By 1955 there were roughly two dozen such research centers engaged almost entirely on work for the three military departments. The nature of the contractual arrangements between the military departments and the universities, other nonprofit organizations, or commercial concerns operating the centers, enables the directors of the centers to carry out their programs free from many of the administrative problems posed for scientific work by governmental procedure and organization.

National Science Foundation

The National Science Foundation was established by Act of Congress in 1950. This culminated a movement which began in 1945 when extensive congressional hearings revealed that an overwhelming majority of the nation's scientists, educators, and business leaders favored the creation of such an agency as had been proposed in Vannevar Bush's report, "Science—The Endless Frontier."

Under the terms of the act of 1950, the foundation's authority is vested in the National Science Board and the director of the foundation. The board consists of 24 members appointed by the President with the advice and consent of the Senate. The director is also named by the President with the advice and consent of the Senate.

The foundation's responsibilities, as set forth in the act, were clarified and elaborated by Executive Order 10521, issued in 1954. Of major importance is the foundation's support of basic research in the sciences through grants to investigators, usually in universities. The foundation has a fellowship program and other programs designed to aid in the training of scientists and in improving the quality of science teaching. It is also concerned with expanding the dissemination of scientific information. It is charged with responsibility for developing and encouraging the pursuit of a national policy for the promotion of basic research and education in the sciences and with appraising the impact of research on industrial development and on the general welfare.

To meet these responsibilities the foundation maintains a staff in Washington which is organized into six principal divisions and offices.

National Aeronautics and Space Administration

One major change in the organization of the Federal Government for scientific activities that has occurred since the publication of the National Science Foundation's study which appears in part above is the absorption of the National Advisory Committee for Aeronautics by the recently created National Aeronautics and Space Administration. The new agency, which will eventually control many of the scientific activities now under the direction of the Department of Defense, has responsibility for all space programs which are not primarily associated with national defense. The area of jurisdiction of this agency is currently being defined. Further information concerning the NASA can be found in *Science* [**128**, 582 (12 Sept. 1958); **128**, 826 (10 Oct. 1958); **128**, 889 (17 Oct. 1958); **128**, 994 (24 Oct. 1958)].

U.S.–Euratom Agreement for Cooperation Signed

An agreement between the United States and the six-nation European Atomic Energy Community (Euratom) was signed on 8 November 1958 in Brussels. The agreement for cooperation in the civil uses of atomic energy has as its major objective the bringing into operation in the Community in the next five to seven years of approximately 1 million electrical kilowatts of nuclear power capacity, using reactor types developed in the United States.

It is expected that the provisions for wide dissemination of information under the program will provide industrial organizations in the Community and the United States with valuable engineering experience, and technological and economic data concerning the operation of nuclear power plants in Europe under conditions that will be nearly competitive with conventionally fueled plants.

The agreement, expected to come into force after Congress convenes in January 1959, contains the major objectives of the United States and Euratom on the joint nuclear power program, whose capital cost, exclusive of fuel, is expected to be about $350 million. These provisions include:

1. Financial guarantees by the United States of up to $90 million for a 10-year operating period with respect to the cost and integrity of the fuel elements required in the reactors;

2. Long-term assurance of an adequate nuclear fuel supply at prices equivalent to those offered to domestic U.S. industries;

3. Guarantee for a 10-year period of a market for the plutonium recovered from the power reactors in the program;

4. Long-term line of credits of up to $135,000,000 to cover a portion of the capital costs of the nuclear power plants; and

5. A long-term assurance by the United States chemical reprocessing services will be available under terms comparable to those then available to U.S. industry.

An integral part of the program is a

joint 10-year research and development project. During the first 5 years the Community and the United States will each contribute up to $50 million to this program. Before the expiration of the first 5 years the participants will determine the financial requirements for the remaining 5 years and will undertake to procure the necessary funds for the program.

The nations which make up the Community are Belgium, France, the Federal Republic of Germany, Italy, Luxembourg, and the Netherlands. The six member countries have a total population of 160 million.

The agreement for cooperation is the product of close and continued negotiations between the United States and Euratom, beginning shortly after the establishment of Euratom on 1 January 1958. The first major step, outlining the scope of the proposed joint undertaking, was accomplished through the signing of a Memorandum of Understanding by representatives of Euratom and the United States in June 1958.

In conformance with U.S. Law, the United States and Euratom then entered into a general international agreement designed to permit cooperation between the United States and Euratom. *Science* 128, 75 (11 July 1958). This preliminary international agreement and the legislative basis for initial U.S. participation in the joint program as contained in the Euratom Cooperation Act of 1958 were approved by Congress in August 1958.

Tuberculosis Infection

The American Trudeau Society reports that there is no drop in the tuberculosis infection rate among young school children, despite a decided drop in death rate in the 10-year period 1947–57. A study, made in Kansas City, Mo., also revealed that in examining grown people in contact with kindergarten children reacting to the tuberculin skin test, active tuberculosis was found at a rate 12 times as high as is found in x-ray surveys of the general population, and that there is a relationship between the size of the reaction and the presence of active tuberculosis among the adult contacts. During the test period, 35,995 kindergarten children were given the tuberculin test, which reveals tuberculosis infection but not necessarily active disease, and the histoplasmin test for histoplasmosis, a fungus disease endemic in the area. Nonreactors, during a seven-year period, were retested in the first grade.

The study was sponsored by the Heart of America Tuberculosis Association and the U.S. Public Health Service. The results were reported in the November issue of *The American Review of Tuberculosis and Pulmonary Diseases,* in a paper by Lawrence E. Wood of the University of Kansas School of Medicine, Michael L. Furcolow, chief, Kansas City Field Station, PHS Communicable Disease Center, and Myron J. Willis of the Communicable Disease Center, Atlanta, Ga.

Control of Outer Space

A draft resolution on the control of outer space was submitted to the United Nations General Assembly on 13 November by 20 countries, including the United States. Henry Cabot Lodge of the United States introduced the resolution. When discussing it, he commented:

"We can use this new dimension to destroy ourselves through the extension of national rivalries into outer space, or we can use this new development as a vehicle for international collaboration and harmony." Lodge observed that the resolution did not deal with missiles, then added: "Candor compels us to admit that agreement on the disarmament aspects of outer space lies in the future. We cannot await a comprehensive disarmament agreement."

The text of the resolution follows:

"The General Assembly,

"Recognizing the common interest of mankind in outer space and that it is the common aim that it should be used for peaceful purposes only,

"Bearing in mind the provision of Article 2, Paragraph 1, of the Charter, which states that 'the organization is based on the principle of the sovereign equality of all its members,'

"Wishing to avoid the extension of present national rivalries into this new field,

"Desiring to promote energetically the fullest exploration and exploitation of outer space for the benefit of mankind,

"Conscious that recent developments in respect of outer space have added a new dimension to man's existence and opened new possibilities for the increase of his knowledge and the improvement of his life,

"Noting the success of the scientific cooperative program of the International Geophysical Year in the exploration of outer space and the decision to continue and expand this type of cooperation,

"Believing that the development of programs of international and scientific cooperation in the peaceful uses of outer space should be vigorously pursued,

"Believing that progress in this field will materially help to achieve the aim that outer space should be used for peaceful purposes only,

"Desiring to obtain the fullest information on the many problems relating to the peaceful uses of outer space before recommending specific programs of international cooperation in this field,

"1. Establishes an ad hoc committee on the peaceful uses of outer space consisting of the representatives of . . . and requests it to report to the Fourteenth General Assembly on the following:

"(a) The activities and resources of the United Nations, its specialized agencies, and of other international bodies relating to the peaceful uses of outer space;

"(b) The area of international cooperation and programs in the peaceful uses of outer space which could appropriately be undertaken under United Nations auspices to the benefit of states irrespective of the state of their economic or scientific development;

"(c) The future United Nations organizational arrangements to facilitate international cooperation in this field;

"(d) The nature of legal problems which may arise in the carrying out of programs to explore outer space;

"2. Requests of the Secretary-General to render appropriate assistance to the above-named committee and to recommend any other steps that might be taken within the existing United Nations framework to encourage the fullest international cooperation for the peaceful uses of outer space."

News Briefs

On 18 November the new Laboratory of Microbiology of the Technological University at Delft, Netherlands, was officially opened. During the dedication ceremony, a bust of the former director, the late professor A. J. Kluyver, was unveiled and presented to the university on behalf of former pupils and personnel of the laboratory.

* * *

The United Nations has announced that the prepublication period for the Proceedings of the Second U.N. International Conference on the Peaceful Uses of Atomic Energy, during which complete sets may be ordered at a special price, has been extended to 31 January 1959. The action was taken to facilitate the budgetary arrangements of institutions unable to purchase the complete set of volumes from their 1958 budgets.

* * *

A new technique for calibrating airborne compasses by "rotating the world" around a stationary aircraft or guided missile has been announced by the Air Research and Development Command and the Sperry Gyroscope Company, Great Neck, N.Y. Developed by Sperry in cooperation with ARDC's Wright Air

Development Center, Ohio, the equipment rotates the earth's magnetic field electronically around the aircraft or missile. This eliminates the time-consuming checks by several men that have been necessary heretofore.

* * *

A small exploratory mission of the International Atomic Energy Agency in Vienna has gone to Cairo to consult with the government of the United Arab Republic on the possible production of uranium phosphate ores and on the production of heavy water. The experts of the mission are B. V. Nevsky of the U.S.S.R. and Victor Thayer of the United States.

Grants, Fellowships, and Awards

General. The National Science Foundation has announced a new program of cooperative graduate fellowships under which approximately 1000 fellowships will be provided for graduate students in the sciences and engineering. Fellows will be selected solely on the basis of ability. This program is in addition to the foundation's regular predoctoral, postdoctoral, senior postdoctoral, and science faculty fellowship programs.

In the first experimental year of operation, applicants may apply to study at one of 115 designated colleges and universities—those which have awarded an average of at least one doctoral degree annually over the last 4 years of record in the disciplines covered. Applicants will apply through the institution of their choice and initially will be evaluated by the faculty. Applications will be forwarded, together with the institution's recommendations, to the NSF.

Tenures of from 9 to 12 months are optional with the fellow. Fellows will receive a basic annual stipend of $2200 from NSF funds. Modest supplemental support may be extended by the institutions themselves to encourage fellows to undertake limited teaching responsibilities. In addition, the foundation will provide to each institution, in lieu of tuition and fees, a fixed amount for each cooperative graduate fellow enrolled at the institution.

Application materials can be obtained from the graduate dean of a participating institution or from the Fellowships Section, Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C. Applications must be submitted to the graduate dean of the participating institution of the applicant's choice *by 15 December.*

Natural sciences. The Weizmann Institute of Science, Rehovoth, Israel, has announced two Chaim Weizmann Memorial Fellowships for 1959–60. These annual fellowships in the natural sciences are tenable for a period of 12 months. They are intended for scientists with several years of postdoctoral research experience. It is expected that the candidate will have worked in a field close enough to one of the subjects under investigation at the Weizmann Institute to be able to join an existing research team.

The stipend includes round-trip fare by air for the scientist and his family and an adequate living allowance in Israel in local currency. The institute endeavors to help find suitable accommodations. Applications should reach the Academic Secretary, Weizmann Institute of Science, Rehovoth, Israel, *not later than 31 December.* Further particulars and application forms may be obtained from the academic secretary.

Science teaching. The National Science Foundation has announced a new program of summer fellowships for graduate teaching assistants. Designed to enable graduate teaching assistants to devote their full summer to study and research, the fellowships, approximately 550 in number, will be offered for study in the sciences and in engineering.

In the first experimental year of operation, 115 colleges and universities which have awarded an average of at least one doctoral degree annually for the last 4 years of record in the disciplines covered will participate in the program. Applicants, who must be citizens of the United States now serving as teaching assistants in these colleges and universities, will apply through their own institutions and will be screened and evaluated initially by their faculties. They will be judged solely on the basis of ability. The applications will be forwarded, together with the institution's recommendations, to the National Science Foundation.

Summer tenures from 8 to 12 weeks may be selected by the fellow. The weekly stipend will range from a minimum $50 up to a maximum of $75 per week, the exact amount to be determined by the fellow's institution according to local conditions. Payment of stipends will be made by the participating institutions from funds provided them for that purpose by the foundation. In addition, the foundation will pay to each institution the tuition and fees of its fellows.

Application materials may be obtained from the graduate dean of a participating institution or from the Fellowships Section, Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C. Teaching assistants in participating institutions must submit their applications to their graduate deans by *15 December.*

Scientists in the News

ALBERT H. COONS, visiting professor of bacteriology and immunology at the Harvard Medical School and career investigator of the American Heart Association, received the eighth annual Kimble Methodology Research Award at the recent Conference of State and Provincial Public Health Laboratory Directors in St. Louis. He was honored for his development of a method for the prompt diagnosis of such infectious virus diseases as influenza, measles, mumps, and chicken pox.

Coons' method uses a fluorescent dye and ultraviolet light to identify infectious disease viruses. The key to the work which Coons and his associates began in 1941 is the fact that antibodies formed in the body to combat disease are specific; for example, an antibody against influenza will react only with an influenza virus. Such antibodies may be tagged with a fluorescent dye so that they will glow under ultraviolet light.

To find a cell infected with a virus such as influenza, serum containing tagged influenza antibodies is put on a slice of tissue. The antibodies will adhere only to the influenza virus. Under a microscope, the specific virus may then be detected and accurately located within the cell.

LAURENCE H. SNYDER, president of the AAAS and of the University of Hawaii, has been invited to serve as president of the next Pacific Science Congress, which is scheduled to be held in Hawaii during the last week of August and the first week of September 1961. The National Academy of Sciences–National Research Council and the Bernice P. Bishop Museum, Honolulu, the representative institutions sponsoring the tenth congress of the Pacific Science Association, issued the invitation to Snyder.

B. Q. WARD, bacteriologist and associate professor of biology at Mississippi Southern College, has been designated director of the Mississippi Institute of Microbiology that has recently been established as a unit of the college's department of biology. The institute is the only organization of its kind in the state. It is essentially a research establishment and is empowered to accept and administer grants.

The staff of the institute also has responsibility for preparing an annual report that is to include recommendations for teaching and course work within the academic department. However, appointment to the faculty of biology at Mississippi Southern does not confer institute membership, nor need a research

worker at the institute teach, but it is expected that institute personnel will normally be composed of those with dual appointments to both organizations.

The following mathematicians have reported new appointments for the academic year 1958–59.

HENRY SCHEFFE, professor at the University of California, Berkeley, will be a visiting professor at Princeton University, where he will work with the Statistical Techniques Research Group.

E. V. SCHENKMAN, professor at Louisiana State University, has been appointed visiting professor at the University of Wisconsin.

SEYMOUR SCHUSTER, associate professor at the Polytechnic Institute of Brooklyn, has been appointed visiting associate professor at Carleton College.

C. H. W. SEDGEWICK, professor at the University of Connecticut, has retired and has accepted a position as statistician in the Bureau of the Census, Washington, D.C.

R. J. SILVERMAN, associate professor on leave from the Illinois Institute of Technology, has been appointed visiting professor at the University of Puerto Rico, Mayaguez.

K. T. SMITH, associate professor on leave from the University of Kansas, has been appointed associate professor at the University of Wisconsin.

CHOY-TAK TAAM, associate professor at Catholic University of America, has been appointed professor at Georgetown University.

J. H. WAHAB, associate professor at Georgia Institute of Technology, has been appointed a professor at Louisiana State University.

R. L. WILSON of Convair, Fort Worth, Tex., has been appointed professor at Ohio Wesleyan University.

YUNG-CHOW WONG, professor on leave from the University of Hong Kong, will be at the Institute for Advanced Study for the first semester, and at the University of Chicago for the second semester.

A. S. FAIRBAIRN, a medical statistician at the Medical Research Council's Statistical Research Unit, London School of Hygiene and Tropical Medicine, London, England, is spending from 4 to 5 months as visiting scientist at the National Institutes of Health, where he is working with Harold F. Dorn of the Biometrics Branch, Division of Research Services.

D. B. HOPE, member of the Medical Research Council's Radiobiological Research Unit, Atomic Energy Research Establishment, Harwell, England, is spending this year at the Rice Institute, Houston, Tex., where he is working with J. Awapara.

Two noted researchers have joined the zoology department at Southern Illinois University: RICHARD KUDO, protozoologist, and RICHARD BLACKWELDER, a specialist in the classification of insects. Kudo is working on the giant amoeba, while Blackwelder is working on animal classification.

Kudo, who left his native Japan in 1915 to teach at Columbia University, retired in 1954 after serving on the University of Illinois faculty for 36 years. Before joining Southern Illinois as visiting professor this fall, he taught for 4 years at Rutgers University and its Institute of Microbiology. He is the author of *Protozoology,* a major reference work in the field.

Blackwelder, for 20 years curator of insects at the U.S. National Museum, taught 2 years at St. John Fisher College before joining Southern Illinois.

JOHN C. BAIARDI, chairman of the department of biology at Long Island University, has been appointed associate dean for scientific development in the university's College of Liberal Arts and Science, Brooklyn. He will continue to serve as chairman of the biology department.

HAROLD H. SMITH, senior geneticist at Brookhaven National Laboratory, has been appointed for a period of 1 year to the staff of the International Atomic Energy Agency, Vienna, Austria, in connection with programs in genetics, biology, and agriculture.

VERL HOUSE, formerly head of the biology department of Radford College, has been named associate professor of genetics in the department of zoology and entomology at Ohio State University.

ARTHUR W. VANCE, former chief engineer of the Astro–Electronic Products Division, Radio Corporation of America, has been named head of the newly formed information processing research department of Hughes Aircraft Company, Culver City, Calif. Prior to joining Hughes, Vance was employed for nearly 30 years by R.C.A. and Westinghouse, where his work concerned television systems and circuits, feedback systems, instruments, analog and digital computers, and fire-control and reconnaissance systems.

FRANK K. SCHOENFELD, vice president, research, B. F. Goodrich Company, has been named recipient of the Industrial Research Institute Medal for 1959. The medal has been awarded annually since 1945 to honor "outstanding accomplishment in leadership in or management of industrial research which contributes broadly to the development of industry or the public welfare." The presentation of the medal to Schoenfeld will take place next May at the annual meeting of the Industrial Research Institute.

Recent Deaths

GEORGE H. BOTSTIBER, Philadelphia, Pa.; 60; biochemist, originally of Vienna, Austria, where he conducted research at the Rudolph Hospital and in the laboratories of the Poliklinik; in this country he was a biochemist in Philadelphia for about 20 years; 13 Aug.

RICHARD M. HITCHENS, St. Louis, Mo.; 53; senior adviser to the director of research and development of the organic Chemicals Division, Monsanto Chemical Company in St. Louis; had been with the company since 1931; 28 Oct.

KENNETH D. JOHNSON, Orleans, Mass.; 60; dean emeritus of the New York School of Social Work, Columbia University; former president of the New York State Welfare Board; 6 Nov.

ROBERT O. MARSH, New Brunswick, N.J.; 69; professor of science at Pembrook College (N.C.) from 1947 until his retirement in 1954; head of the department of hygiene and biology at Gettysburg College (Pa.), 1924–39; 10 Nov.

JOHN T. NICHOLS, New York, N.Y.; 75; curator of the department of recent fish at the American Museum of Natural History from 1927 until his retirement in 1952; had been with the museum for almost 50 years; founder and president of the American Society of Ichthyologists and Herpetologists; founder of *Copeia,* a magazine which deals with coldblooded vertebrates; 10 Nov.

Sir GILBERT WALKER, London, England; 90; mathematician and professor of meteorology at the Imperial College of Science and Technology in London; director-general of observatories in India, 1903–24; transformed the predictions of India's monsoons from augury to a science; 5 Nov.

AUGUSTUS P. WEST, Tampa, Fla.; 80; retired research chemist with the National Bureau of Standards, Washington, D.C.; chief of the Division of Chemical Research, Bureau of Science, Manila, Philippines, 1933–42; conducted research in the Philippines in association with the University of the Philippines and the Bureau of Science in Manila for 35 years; 24 Oct.

BENJAMIN P. YOUNG, Ithaca, N.Y.; 71; professor emeritus of zoology at Cornell University; retired in 1952 after having been connected with the university for 35 years; 10 Oct.

Book Reviews

D'Arcy Wentworth Thompson. The scholar-naturalist, 1860–1948. Ruth D'Arcy Thompson. Oxford University Press, New York, 1958. xi + 244 pp. $4.

It has not been customary, during the past several generations, to write books about biology subjectively. *Growth and Form,* which appeared first in 1917 and again in 1942, greatly revised and expanded, has seemed an outstanding exception. This is a book with many virtues, the first of which is surely that it develops an original and stimulating idea about the relationships between biology and mathematics. Almost as important, however, is the fact that both its wonderful style and its diversified content let the personality of its author shine through. It brings the reader to share the enthusiasm and love of D'Arcy Thompson not only for an idea, not only for literature and for wisdom, but particularly for the creatures of the earth, the waters, and the skies. The reader envisions the author as having been a sort of latter-day Aristotle, as happy in prowling the fish markets and shores of the northern ocean as was his predecessor who frequented those which rimmed a more temperate sea. His writings are genial, in more than one sense of the word, and they seem to reflect the mood of a contented and successful man.

This biography by his daughter amends the impression. He was happy indeed in his remarkable family, but he was fretful and unhappy in his isolation in Dundee—where he spent over 30 years, including those in which he completed the first edition of *Growth and Form*—and frankly embittered at his lack of recognition. Though he was eventually to serve as its vice president, it was only in 1916, in the middle of his sixth decade, that he was elected a fellow of the Royal Society. It comes as a shock, too, to the present generation, which unthinkingly speaks of evolution and mechanism in the same half breath, to be reminded that *Growth and Form,* when it first appeared, was considered daringly antievolutionary.

This biography is of value, however, not only for what it tells of things of which we may not have known but also for what it confirms of things we have felt about the quality of D'Arcy as a person. His daughter's text, which is ably written in its own right, is richly interspersed with excerpts from his own letters and writings, and all that stands here, in his own words or his daughter's, attests to his honesty, simplicity, and kindness. This book is recommended not only to those who are interested in the growth and form of an idea but as strongly to those for whom the growth and form of humanity has meaning.

JANE OPPENHEIMER
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Biological Ultrastructure. Arne Engström and J. B. Finean. Academic Press, New York, 1958. ix + 326 pp. Illus. $8.

The field of biological fine structure is currently in a state of very rapid expansion, and as a result there exists a great need for suitable source books. The present volume is valuable from this point of view. As stated in their preface, the aim of the authors has been to introduce the rather extensive field of biological ultrastructure to the student and also, rather importantly, to the research worker in various fields of medical and biological science who is becoming more interested in the fine structure of the systems he studies in relation to their biophysical and biochemical properties.

The authors have adopted the useful device of beginning with the simple building blocks, progressing to the larger molecules, and finally considering a number of biological systems of current interest. While this approach is useful from the standpoint of teaching, it inevitably reduces the coverage of any particular system, so that the specialist in a given field is likely to find relatively little of interest in his specialty. The book is illustrated with a considerable number of electron micrographs, x-ray diffraction diagrams, and line drawings, which, although generally of good quality, could, in some instances at least, have been chosen with a more critical eye.

After a short introductory chapter, the methods used in ultrastructural research are presented rather briefly. The essentials of the various methods of microscopy (phase contrast, interference, polarization, x-ray, and electron microscopy), spectroscopic techniques, and x-ray diffraction are outlined in a concise and readable form. Following this is a chapter on principles of molecular structure, beginning with simple atomic and molecular theory and progressing to a consideration of more complex aggregations, such as liquid crystals and gels, and their relation to the structure of water. The bulk of the book is taken up with a more detailed consideration of the roles of proteins, lipids, carbohydrates, nucleic acids, and mineral salts, the last-mentioned discussion being a discourse on mineralized tissues, both normal and pathological.

As would be expected, the authors are at their best in those chapters nearest to their own particular specialties, the lipid systems and mineral salts. The material in these various chapters is well presented, on the whole, but the more experienced worker in the field will be handicapped by the paucity of references, and the specialist will recognize various inaccuracies—for instance, the concept that the structure of native collagen is not easily reconciled with a macromolecular unit about 2800 angstroms in length. On the contrary, present results of refined physical chemical measurements and of electron microscopy are overwhelmingly in favor of such a unit. Again, the concept of linear aggregation of globular units in fibrogenesis is presented as an established fact, whereas in reality there are at least several important proteins in which there is no evidence for such a view, and in which, on the contrary, the available data are strongly in favor of highly asymmetric rodlike monomeric units.

On the whole, the book is a useful addition to the literature in this field, but it could reasonably be argued that its rather general title should have been reserved for a very much more comprehensive work.

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Medical Sociology. Theory, scope and method. Norman G. Hawkins. Thomas, Springfield, Ill., 1958. xx + 290 pp. $6.75.

The most appropriate comment about this book is given by the author in the foreword: "This book is not intended to be read lightly, nor is it intended for light readers. . . . Nor is this intended

as a treatise which will establish a grand new unified 'system' with carefully elaborated postulates, propositions, and formal logic." Unquestionably it is a difficult book to read and one easy to criticize. The editorial work has not been of high quality, consequently loose statements have been allowed to remain. For example, in the chapter on "Methods of analysis," we find, "A normal distribution, in turn, is what happens when an infinite number of cases are arrayed by pure chance on an infinite straight progression of some quality" (page 167), and "Z^2 (the square of the standard deviation in a normal distribution)" page 197). These and similar statements detract from the value of the author's ideas on the proper application of statistical methods.

Aside from its editorial shortcomings, this work suffers from lack of organization, as the author apparently realizes. The order of presentation consists of an "Introduction," in which medical sociology is defined as the behavioral science specialty which encompasses demography and is concerned with the study of mental disorders and chronic disease in the population, of hospital structure and utilization of medical services. The next chapter, on the "Matrix of man," is devoted to theoretical considerations and an attempt to integrate concepts of culture theory with those of physiology. For some reason, here, he feels he must attack Darwin and Freud. This chapter is followed by one which summarily reviews studies dealing with ageing and with diseases such as schizophrenia, alcoholism, and tuberculosis; by another mainly concerned with rules of conduct for the medical sociologists who become involved in interdisciplinary studies; by another which briefly discusses social changes and health problems; and, finally, by the chapter on "Methods of analysis" already mentioned.

In brief, this book is a series of essays based on the author's own work and reflections on the work of others, with a number of good, bad, and indifferent ideas in varying stages of maturation thrown at the reader. The author has obviously read widely in public health.

ANTONIO CIOCCO
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Elementary Statistical Physics. C. Kittel. Wiley, New York; Chapman & Hall, London, 1958. x + 228 pp. $8.

The field of statistical mechanics and kinetic theory is one which finds many applications in the description of both microscopic and macroscopic physical phenomena. Much of the variety of application of these fields is reflected in this book—an expanded set of lecture notes—by Kittel. Unfortunately there are many topics of major interest that are not included, and those subjects that are treated are frequently given a sketchy analysis.

Several of the topics discussed here that are not found in any other book on statistical mechanics or kinetic theory are the concept of negative temperature, the representation of random noise by a Fourier series, the Wiener-Khintchine theorem, the Fokker-Planck equation, the Onsager relations for irreversible processes, and the Kramers-Kronig relations. The treatment given these topics, although brief, might be stimulating enough to prompt students to pursue the various topics further. However, there are many topics of at least equal or even greater importance that have been omitted. Among these are the theory of imperfect gases and cooperative phenomena and methods useful in the theory of liquids, such as the use of the radial distribution function and the methods pioneered by Kirkwood, Born, and Green.

It is difficult to recommend this book because of its many omissions and because of its uncritical approach to the problems of statistical physics. The statistical approach to physical problems is fraught with subtlety, little of which appears in this book. Perhaps a book on calculation methods of statistical physics is needed; a really good one would have to be far more complete than this, both in philosophy and in coverage.

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Information Indexing and Subject Cataloging: Alphabetic: Classified: Coordinate: Mechanical. John Metcalfe. Scarecrow Press, New York, 1957. 338 pp. $6.50.

The best advice that a trained librarian can come up with for the tyros determined to standardize and to mechanize the retrieval process is that old jingle from New York horsecar days (page 211),

"Punch brothers, punch, punch with care,
Punch in the presence of the passengaire."

To suggest caution is always good advice to give but awkward to follow. Of what should one be cautious? John Metcalfe, an eminent Australian librarian, has done his best to map the byways frequented by unwary librarians and now unduly popular among documentalists. This makes the advice even harder to take, for the past mistakes of others never seem similar to one's own newest and dearest project.

Until now, no trained librarian has deigned to define and to evaluate the new field of documentation in terms of library systems. As long as machines are designed to retrieve bibliographic references, the particular worth of library experience should be recognized and exploited. For hundreds of years, librarians have tusseled to get the right book to each and every would-be reader. They have acquired understanding of the tricky process whereby people ask for one thing while wanting another.

Metcalf starts with fundamentals. What is being classified or indexed? Is it existing information about various subjects, or are the subjects themselves being classified? On this simple-appearing dichotomy have foundered many retrieval systems, of both library and documentation types. The organization of all knowledge is the chimera that has seduced them. Metcalfe (page 199) takes J. W. Perry particularly to task on this point: "We do not choose a genus or class for such things as dogs because it is more natural, or scientific or permanent; this is the talk of Bliss and the metaphysical 'order of the sciences' school. We choose it because there is general literature on the genus and special literature on its species, whether it is a genus or class of animals, for example, by their anatomy or by their use."

Tailoring a classification scheme to the needs of a particular collection was the example set by the Library of Congress, and today this method still has many skillful practitioners [see S. Herner and R. S. Meyer, "Classifying and indexing for the special library," *Science* **125**, 799 (1957)].

Another necessary distinction is between finding information and communicating information, or between "indication" and "communication," as Metcalfe expresses it (page 25). Indication consists in describing information in a particular physical form, with word clues for the limited purposes of retrieval. Fortunately, it is not necessary to communicate the information itself in order to perform retrieval successfully.

There is a big difference, linguistically and logically, between providing references to documents where there is a high probability that the answer will be found and providing actual answers to a question. One difference is that the latter requires full sentence structure while the former does not. If this difference between indication and communication was generally understood by documentalists, it would not have been necessary for the logician Yehoshua Bar-Hillel to deliver a homily on the subject [Y. Bar-Hillel, "A Logician's reaction to recent theorizing on information search systems," *Am. Document.* 8, 103 (1957)]. This article may seem to be a negative contribution, but then clarity and con-

sistency are purgative processes and so can only be applied to existing concepts and formulations.

According to Metcalfe, there are two basic ways of retrieving things (page 22.) The first is by placing them in a known order and then selecting the correct subdivision in which to look. The second is by sorting through all things which have been kept and, by individual perusal, determining which is wanted. Any kind of known order will do, from an arbitrary one, such as the alphabet, to a meaningful one, such as a classification system. This is the core of librarianship—the choice and application of a known order to a collection of records.

Sorting through any but the smallest collection is an awkward and arduous process for human beings. Fortunately, some machines seem to be quite good at sorting. But, interestingly enough, machine limits for efficient sorting are soon reached, and known order becomes relevant again.

Again according to Metcalfe, there are two main costs in running a retrieval system: (i) that of "compilation"—of input, of adding new material to the system, and (ii) that of "consultation"—of output, of providing reference service upon request (page 26). The frequency and variety of types of consultation should determine the nature of the input. It is only advisable to concentrate on the compilation phase if the needs and resources of a search system are not only well known but relatively stable. Metcalfe admits that lower compilation costs are probably possible in the documentation systems but suspects that the original economy may be offset later by the need for "extra indexing" tools (pages 172–5 and 201–8). "Extra indexing" identifies combinations of terms, whether on a generic or other basis, which lead to fruitful searches in a particular collection. There are two answers to this argument. One is that so far most uniterm or descriptor installations have not required such an addition. The second is that if "extra indexing" seems useful, the mechanized systems are in a particularly good position to provide such extras at a minimum cost. C. L. Bernier of *Chemical Abstracts* has been presenting some good arguments for utilizing such printouts from mechanized systems instead of waiting until a particular question arises before going to a machine [C. L. Bernier, "Correlative indexes," *Am. Document.* 7 (Oct. 1956), and later issues].

Readers may find the structure of the book unusually complex and Metcalfe's style of writing difficult, but none will find him dull or wishy-washy. He raps sharply so many knuckles that one cannot resist pointing out one of his own *non sequiturs,* that of subsuming the Zatocode system of Mooers, for which he has a 1951 reference, under the Coordinate Indexing system of Taube, for which he uses 1953 and 1954 references. Not only is this chronologically incorrect, but it is instructive to see in what respects Coordinate Indexing has increasingly deviated from the Zatocode original.

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Gmelins Handbuch der Anorganischen Chemie. System No. 3, sec 3: *Oxygen.* xi + 518 pp. Illus. $67.92. System No. 42: *Zirconium.* xxxvii + 448 pp. Illus. $63.84. System No. 43, supplement: *Hafnium.* ii + 23 pp. Illus. $5.28. System No. 45, supplement: *Germanium.* xliv + 576 pp. Illus. $80.88. Verlag Chemie, Weinheim/Bergstrasse, Germany, 1958.

The recently published sections of *Gmelins Handbuch* have several new features which make it easier for the chemist to use this valuable treatise. On the inside covers the chemical elements are listed by system numbers. These numbers are not the atomic numbers of the elements of the periodic chart, but are designed to arrange the elements in a way that permits systematic and comprehensive treatment, in one place, of all the major anionic groups for each cation-forming element. As a result, all major compounds of an element are classified systematically in the volume pertaining to that element. For example, the volume of iron (59) contains all known combinations with elements from system No. 1 (rare gases) to 58 (cobalt).

A desired compound or combination will be found in the volume with the highest system number. The compound Fe_2O_3 is listed in the volume on iron (59), but not in that on oxygen (3). On the other hand, Pt_3Fe will be found in the volume on platinum (68).

Within a volume, a compound of three or more elements is grouped with the system number next lower than that of the volume element. For example, rubidium chlorobromide will be found in the rubidium volume (24) under rubidium and bromine; and rubidium bromoiodide, under rubidium and iodine. The system numbers of chlorine, bromine, and iodine are 6, 7, and 8, respectively.

With an addition compound, such as $FeBr_2 \cdot 4C_5H_5N$, the compound is listed in the volume on iron under iron and bromine. With an ammonium-type compound, such as $C_5H_6N[FeBr_4]$, the compound is listed under iron and ammonium and not under iron and organic bases.

Chemical reactions are generally described under each reaction component and also under the reaction products.

The directions for using *Gmelins Handbuch* are given in both German and English and are illustrated by examples. New departures designed to make the *Handbuch* more easily consulted are the bilingual index and, in the case of the supplementary section on hafnium, there are catchwords in English on the page margins.

Oxygen. This new volume is devoted to elementary oxygen and covers the preparation of oxygen, separation and enrichment of oxygen isotopes, physical properties, and electrochemical reactions, and reactions in hydrogen-oxygen mixtures. The literature is covered through 1949.

Zirconium and Hafnium. The zirconium volume and the hafnium supplement to the hafnium volume published in 1941 complete the treatment of subgroup 4B (Ti, Zr, Hf, Th) in the 8th edition of *Gmelins Handbuch.*

The volume on zirconium covers the history of the element, its occurrence, ore dressing, metallurgy, technology, properties, analysis, and its major compounds with other elements in the preceding system numbers, ending with titanium. The literature search was carried through 1949.

The supplementary section on hafnium brings the information on this element through 1949.

Germanium. The volume on germanium is a supplement to the volume published in 1931 and covers the literature from 1931 to 1953, and, in the case of the optical, electrical, and photoelectric properties, to the end of 1954.

Due to the interest in germanium in recent years, a considerable amount of material has appeared. This is reflected in the fact that the supplementary volume is over 9 times the size of the original volume.

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Sherrington. Physiologist, philosopher and poet. Lord Cohen of Birkenhead. Thomas, Springfield, Ill., 1958. 108 pp. Illus.

In 1948, when Charles Scott Sherrington was 90, the University of Liverpool created a lectureship in his honor in recognition of his great and distinguished contributions to physiology and medicine. Among those who, in addition to other designations, are now known as Sherrington lecturers, we note E. D. Adrian of Cambridge, John F. Fulton of Yale, Geoffrey Jefferson of Manchester, and Wilder Penfield of Montreal. To this brilliant company is now added Lord

Cohen of Birkenhead, professor of medicine at Liverpool University.

As a clinical neurologist and friend of Sherrington, Cohen is well qualified to describe and assess the work of the man who, during his life-time, became known as "the philosopher of the nervous system." The author begins by stating, "I propose in this first lecture briefly to sketch Sherrington's life and work; and in the second and third to describe and assess with the aid of diagrams and films, his contributions to learning, not for the specialist but for the informed non-specialist, so that he may comprehend why Sherrington has been regarded as the most profound student of the nervous system the world has yet known, and so that he may marvel at a productivity—monumental, magnificent, and sustained—covering a span of 70 years, and which embraced not only science, but also philosophy, history and poetry."

The slim volume which contains the substance of these lectures is beautiful in format, informative in content, and charming in style. Yet it must not be supposed that this book constitutes an adequate biography of one of the greatest scientific minds of modern times. It is rather a provocatively tempting appetizer for a more robust feast, which we may hope will be not too long in appearing.

As his life-span (1857–1952) indicates, Sherrington lived through one of the most exciting centuries in human history, and he made notable contributions to his era. His early education began in 1871 in an English grammar school, where, as he once remarked, "science was socially not quite the thing." His life ended at a time when we are beginning to recognize belatedly that a scientific education is a necessary prerequisite for survival.

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Publications of the World Health Organization, 1947–1957. A bibliography. World Health Organization, Geneva, 1958 (order from Columbia University Press, New York). 128 pp. $3.25.

This bibliography consists of 1915 items published by WHO from 1947 to the end of 1957. It includes all articles published in the *Bulletin of the World Health Organization*, vols. 1–17; articles published in the *Chronicle of the World Health Organization*, vols. 1–11, on matters not fully covered in other WHO publications; survey articles published in the *International Digest of Health Legislation*, vols. 1–8; articles and statistics (other than regularly recurring features) published in the *Epidemiological and Vital Statistics Report*, vols. 1–10; all numbers of the *World Health Organization: Technical Reports Series* from No. 1 to No. 141, including important annexes; all numbers of the *Official Records of the World Health Organization* from No. 1 to No. 81, including important annexes; all numbers of the *World Health Organization: Monograph Series* from No. 1 to No. 36, including the chapters contributed by individual authors in symposia and other collected works; supplements to the *Weekly Epidemiological Record*; and occasional publications such as the *World Directory of Medical Schools* and the *Pharmacopoea Internationalis*. It does not include mimeographed documents which are limited in distribution. It includes an index of authors and an index of countries.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, *but to the publisher or agency sponsoring the publication.)*

Expert Committee on Water Fluoridation, First Report. WHO Tech. Rept. Ser., No. 146. World Health Organization, Geneva, 1958 (order from Columbia Univ. Press, New York). 25 pp. $0.30.

Experimental Studies on the Nature of Species. vol. IV, *Genetics Structure of Ecological Races.* Jens Clausen and William M. Hiesey. Carnegie Institution of Washington, Washington, 1958. 319 pp. Paper, $4.25; cloth, $4.75.

The Guinea Pig in Research. Biology, nutrition, physiology. Publ. No. 557. Mary Elizabeth Reid. Human Factors Research Bureau, Inc., Washington 4, 1958. 87 pp. $2.

Gyro Primer. Norden Div., United Aircraft Corp., Commack, N.Y., 1958. 66 pp.

International Scientific Radio Union, Proceedings of the XIIth General Assembly. Held in Boulder, Colo., 22 August–5 September 1957. vol. XI, pt. 5, *On Radioastronomy.* General Secretariat of the U.R.S.I., 7, Place Emile Danco, Brussels, Belgium, 1958. 148 pp. $4.

The Marine Fish Catch of California, 1955–1956, with Rockfish Review. Fish Bull. No. 105. Marine Resources Operations Staff. California Dept. of Fish and Game, Sacramento, 1958. 104 pp.

Needed Expansion of Facilities for Higher Education. How much will it cost? John D. Long, assisted by J. B. Black, Jr. American Council on Education, Washington, 1958. 43 pp.

New Jersey's Place in Cultural History, 1600 B.C. to A.D. *1625.* A comparative exhibition. Catalog. New Jersey State Museum, Trention, 1958. 36 pp.

New Steroid Compounds with Progestational Activity. Annals, vol. 71, art. 5. Abraham E. Rakoff, Consulting Ed. New York Acad. of Sciences, New York, 1958. 28 pp.

New York Foundation, Two-Year Report, 1956–1957. The Foundation, New York, 1958. 41 pp.

Protein Requirements. Report of the FAO Committee, Rome, Italy, 24–31 October 1955. FAO Nutritional Studies No. 16. Food and Agriculture Organization of the United Nations, Rome, 1957. 52 pp.

Simple Methods of Contraception. An assessment of their medical, moral and social implications. Winfield Best and Frederick S. Jaffe, Eds. Planned Parenthood Federation of America, New York 22, 1958. 63 pp.

An Oceanographic Description of the Eastern Tropical Pacific. Bulletin of the Scripps Institution of Oceanography, vol. 7, No. 3. Warren S. Wooster and Townsend Cromwell. Univ. of California Press, Berkeley, 1958. $5. 114 pp.

Psychological Cinema Register, Catalog 1958, 1959, 1960. The Register, Pennsylvania State University, University Park, 1958. 105 pp.

Recommendations on Undergraduate Curricula in the Biological Sciences. Report of a conference held at Washington, D.C., 8–9 December 1956, and Chapel Hill, N.C., 1–4 April 1957. Publ. 578. Willis H. Johnson, Conference Chairman. National Acad. of Sciences–National Research Council, Washington, 1958. 86 pp. $1.75.

Report on Meeting of Ad Hoc *Committee on Scaling Mesometeorological Phenomena.* Held at Argonne National Laboratory, 15–17 May 1957. ANL-5869. R. C. Wanta and H. Moses, Eds. U.S. Public Health Service and Argonne National Laboratory, Lemont, Ill., 1958. 26 pp.

Strokes. A guide for the family. American Heart Assoc., New York, 1958. 18 pp.

Studies of Devonian Algae. Quarterly of the Colorado School of Mines, vol. 53, No. 2. J. Harlan Johnson and Kenji Konishi. Colorado School of Mines, Golden, 1958. 114 pp. $1.50.

Symposium on Tritium in Tracer Applications, Proceedings. New England Nuclear Corp., Atomic Associates, Inc., Packard Instruments Co., Inc. New England Nuclear Corp., 575 Albany St., Boston, Mass., 1958. 40 pp.

Thirteenth Annual Report, Midwest Research Institute. Midwest Research Inst., Kansas City, Mo., 1958. 16 pp.

Comparative Biosystematics and Life History of the Nuthatches Sitta Pygmaea and Sitta Pusilla. Publ. in Zoology, vol. 56, No. 2. Robert A. Norris. 182 pp. $3.50. *Variation and Systematic Relationships within the Salamander Genus* Taricha. Publ. in Zoology, vol. 56, No. 3. William J. Riemer. 90 pp. $2. Univ. of California Press, Berkeley, 1958.

Beach Erosion Board, Annual Bulletin. vol. 12, July 1958. 115 pp. *Movement of Bottom Sediment in Coastal Waters by Currents and Waves; Measurements with the Aid of Radioactive Tracers in the Netherlands.* Tech. Memo. No. 105. 56 pp. *Laboratory Study of Breaking Wave Forces on Piles.* Tech. Memo. No. 106. 24 pp. Beach Erosion Board, Corps of Engineers, Department of the Army, Washington 25, 1958.

Institut Pasteur du Viêt-Nam, rapport annuel sur le fonctionnement technique, année 1957. The Institute, 1958. 137 pp.

Reports

Complement Fixation with a Mouse Tumor Virus (S.E. Polyoma)

Abstract. Complement fixation tests with tissue-culture antigens indicated that polyoma virus is serologically unrelated to a wide variety of known viruses; antibody developed uniformly in mice given virus intraperitoneally or intranasally and was found in normal animals of several mouse colonies but not in human beings.

Stewart *et al.* (*1*) have reported the isolation of a virus in tissue culture from several types of mouse neoplasms, including filtrate-induced parotid gland tumors (*2*) and a transplantable leukemia. The virus grown in tissue culture produces a variety of tumors in mice, developing after incubation periods as short as 3 to 4 months. Eddy and her coworkers reported that the agent produces multiple fibrosarcomas and hemangiomas in suckling hamsters (*3*) and cytopathic effects in mouse embryo tissue cultures (*4*). More recently hemagglutination (HA) by the agent and the detection of antibodies by hemagglutination inhibition (HI) tests were reported (*5*). This report describes the development of a complement fixation (CF) test with the polyoma virus, and some of its applications.

Three polyoma strains were studied; two strains (Nos. 3919 and 6069) were received from S. E. Stewart and B. E. Eddy, and the third strain (LID-1) was established in tissue culture in this laboratory. Complement fixation antigens and antisera prepared from these three strains gave reciprocal cross reactions with each other. Since in preliminary tests the LID-1 strain gave higher titers, this strain was used for most of the tests reported here.

Complement fixation antigens were prepared by infection of 8- or 32-oz flask cultures of trypsinized whole mouse embryo; the cultures were prepared by seeding the bottles with 15 or 40 ml, respectively, of a 1:200 dilution of packed cells in a growth medium consisting of 10-percent human serum in Eagle's basal medium. At the time of virus inoculation, the medium was changed to Eagle's basal medium with or without 5-percent horse serum. Fluids were harvested once or twice weekly, and when cytopathic effects were generalized, the tissue was harvested with the supernatant fluid. Individual fluids were tested for antigen against 8 to 16 units of standard mouse antiserum. Pooled antigens titering 1:4 were stored at – 60°C and were used unheated. A modified Bengtson procedure was used (*6*).

Standard mouse antiserum was prepared by intraperitoneal inoculation of adult Swiss mice (National Institutes of Health "general purpose" mice) with 0.2 ml of undiluted tissue culture fluid; the mice were bled 3 weeks later. The standard serum titered from 1:320 to 1:640 in CF tests against polyoma virus antigen and was negative at a 1:10 dilution against control antigen prepared from uninfected mouse embryo tissue cultures. This serum titered 1:2560 in HI tests and 1:1280 in tissue culture neutralization tests performed according to the procedure for adenoviruses (*7*), and it prevented development of tumors in suckling hamsters during a 20-day observation period to a titer of 1:1000 (*8*). Control sera, prepared by comparable inoculation of mice with fluid from uninoculated tissue cultures, were negative in CF when tested at a 1:10 dilution against virus and control antigens. Similar tests with immune and control hamster sera gave results essentially identical to those obtained with the mouse sera. Hyperimmune guinea pig sera also reacted specifically with the virus antigens.

Complement fixing antibody developed regularly in newborn and adult Swiss mice given high dilutions of virus intraperitoneally or low dilutions intranasally. Suckling hamsters developed antibody, as well as tumors, after intranasal administration of virus. The susceptibility to infection by the intranasal route suggests that airborne dissemination may be of importance in natural spread of the mouse infection, and that spontaneous cross infection may be a problem in laboratories working with the agent.

Complement fixation antigen, as well as HA activity and infectivity, sedimented into the pellet when tissue-culture fluids were centrifuged at 20,000 rev/min for 2 hours in a Spinco No. 40 rotor (23,360*g*, average); this procedure was of much value for concentrating both the virus and the antigen. As yet, a soluble antigen has not been demonstrated.

In sera of individual mice from naturally infected stocks, CF antibody was invariably accompanied by HI and hamster tumor neutralizing antibodies; however, the CF test was somewhat less sensitive for detection of antibody, since mice with low titer HI and neutralizing antibody were often negative in CF tests.

The LID-1 strain CF antigen did not react with potent antiserums, prepared in mice, guinea pigs, or monkeys, against LCM, mouse salivary gland virus, Coxsackie A types 1 to 19, Coxsackie B types 1 to 5, ECHO types 1 to 20, or poliovirus types 1 to 3. Also, mouse antiserum to the LID-1 strain did not react in CF with the soluble antigens of LCM; influenza A, B, and C; Sendai; hemadsorption virus types 1 and 2; or the adenovirus common CF antigen (*9*).

Young adults and retired breeders of a number of mouse stocks have been surveyed for CF and HI antibody (*10*); at present, antibody has been found, in varying percentages of animals, in certain stocks of C3H, AKR, DBA, RF, C57Br, C58, and Stoli mice. Antibody has not been detected in the stocks of A, STR/N, PRI, CFW/N, BALB/CAnN, BRSUNT/N, or BT mice that have been tested; however, more extensive testing is needed. In positive stocks, antibody was found chiefly in mice over 6 months of age. Although mice with filtrate-induced parotid tumors or leukemias (Gross) were invariably positive, mice with spontaneous leukemias or mice from lines with high rates of spontaneous leukemia were generally negative. Approximately 80 C3H and DBA mice of several sublines carrying the Bittner milk agent which had developed mammary tumors were tested and were found to be consistently negative for CF and HI antibody to polyoma virus; nontumorous mice of these same sublines were also negative. Mice inoculated with the hematopoietic tumor-including virus described by Friend (*11*) did not develop antibody to polyoma virus. These data suggest that polyoma is immunologically distinct from the Bittner and Friend agents, and

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the refernece and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

from the etiologic agents or factors responsible for a number of spontaneous mouse leukemias as well.

It is interesting that C3H/P mice—a strain in which no antibody has so far been found in uninoculated animals—frequently developed CF and HI antibody to the S.E. polyoma virus following inoculation with the C3H leukemia described by Schoolman, Schwartz, and Szanto (*12*); of seven groups of mice receiving tumor extracts and tumor filtrates, at three passage levels, all pooled sera were positive, as were pooled sera of two of three groups inoculated with brain extracts of mice carrying the transplantable tumor. However, of the pooled sera of five groups inoculated with brain filtrates, none of which developed leukemia, only one had antibody. Whether the apparent presence of S.E. polyoma virus in this leukemia bears any relationship to the reported transmissibility of the leukemia by filtrates, as described by Schoolman *et al.*, or represents fortuitous contamination remains to be determined.

Sera from 162 human beings were tested for CF antibody; a 1 : 8 serum dilution was tested against 2 units of S.E. polyoma antigen. The persons tested included 25 healthy adults, 65 healthy children from 1 to 4 years of age, and 72 persons, mostly adults, with solid tumors or leukemia. All tests were completely negative. This absence of reactions indicates that the S.E. polyoma virus does not share common CF antigens with prevalent human viruses such as the adenoviruses, the Coxsackie, ECHO, and polioviruses, the herpes simplex virus, the salivary gland virus, and the human myxoviruses, to which CF antibodies are commonly present in human sera. It also suggests that the polyoma virus does not share CF antigens with hypothetical viruses responsible for the tumors in the patients studied.

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References and Notes

1. S. E. Stewart, B. E. Eddy, A. M. Gochenour, N. G. Borgese, G. E. Grubbs, *Virology* **3**, 360 (1957); S. E. Stewart, B. E. Eddy, N. G. Borgese, *J. Natl. Cancer Inst.* **20**, 1223 (1958).
2. L. Gross, *Proc. Soc. Exptl. Biol. Med.* **83**, 414 (1953); S. E. Stewart, *Anat. Record* **117**, 532 (1953).
3. B. E. Eddy, S. E. Stewart, R. Young, G. B. Mider, *J. Natl. Cancer Inst.* **20**, 747 (1958).
4. B. E. Eddy, S. E. Stewart, W. Berkeley, *Proc. Soc. Exptl. Biol. Med.* **98**, 848 (1958).
5. B. E. Eddy, W. P. Rowe, J. W. Hartley, S. E. Stewart, R. J. Huebner, *Virology* **6**, 290 (1958).
6. P. Halonen and R. J. Huebner, *Proc. Soc. Exptl. Biol. Med.* **97**, 530 (1958).
7. W. P. Rowe, R. J. Huebner, J. W. Hartley, T. G. Ward, R. H. Parrott, *Am. J. Hyg.* **61**, 197 (1955).
8. S. E. Stewart and B. E. Eddy, in *Perspectives in Virology*, in press.
9. Dr. Robert Chanock and Dr. Leon Rosen generously supplied reagents for these CF tests.
10. We are indebted to Dr. Howard B. Andervont, Dr. Ludwik Gross, Dr. George E. Jay, Jr., Dr. Lloyd W. Law, and Samuel M. Poiley for supplying mice for these surveys.
11. C. Friend, *J. Exptl. Med.* **105**, 307 (1957).
12. H. M. Schoolman, S. O. Schwartz, P. B. Szanto, paper presented at the American Association for Cancer Research, Philadelphia, 11–13 Apr. 1958.

19 June 1958

Fertility in Two Haploids of Solanum tuberosum

Haploid plants ($2n = 24$) of several selections of the common potato, *Solanum tuberosum* L. ($2n = 48$), have been obtained (*1*). These plants were found among seedling progenies of interspecific matings designed to make detection of parthenogenetic individuals relatively easy. Haploids of this species represent tools of potential value for future potato investigations in both applied and theoretical areas of research. The realization of such potentialities is dependent initially upon a reasonable level of fertility in the haploid individuals.

This is a preliminary report (*2*) on the fertility of two haploids of *S. tuberosum*. Fertility has been measured in two ways: (i) by the percentage of good pollen as determined from mature anthers squashed and stained in acetocarmine and (ii) by the results of crosses with other tuber-bearing species.

One haploid, US-W1, from the commercial variety Katahdin, is highly pollen-fertile. From 60 to 75 percent of the pollen grains are plump and stain with acetocarmine (Fig. 1). A limited number of attempts to self-pollinate this individual have not produced any fruit. This may be due to self-incompatibility, which is known to be the usual situation in 24-chromosome, tuber-bearing species of *Solanum* (*3*). However, a larger number of self-pollinations must be attempted before self-incompatibility can be definitely established for the US-W1 haploid.

Pollen from this plant was used in matings with four 24-chromosome, tuber-bearing *Solanum* species [*S. kurtzianum*, P.I. 175434 (formerly *S. macolae*); *S. neohawkesii*, P.I. 210044; *S. phureja*, P.I. 195191, and P.I. 195198 (formerly *S. kesselbrenneri* and *S. rybinii*, respectively); and *S. simplicifolium*, P.I. 218224] (*4*). All these matings resulted in the formation of fruits, each of which contained many viable seeds. This haploid has also been successfully crossed to a selection of *S. tuberosum*.

Meiosis was fairly regular in the US-W1 haploid plant. Twelve bivalents were present at first metaphase in over two-thirds of the microsporocytes examined. A similar regularity in meiosis was observed by Ivanovskaja (*5*) in a haploid of *S. tuberosum* variety Aurora.

Another haploid, US-W3, from breeding selection Minn. 15-2-10-1-2, is only slightly pollen-fertile. The majority of the pollen grains are small, shrunken, and only 5 to 15 percent stain with acetocarmine (Fig. 1). This haploid has failed as a staminate parent in the few crosses attempted to date. The high degree of male sterility was not surprising in view of the cytological findings. Less than 10 percent of the microsporocytes contained 12 bivalents at first metaphase. Univalents were frequent, and the majority of the tetrads contained micronuclei. Multivalents, especially quadrivalents, as well as chromatid bridges, were also present. When this haploid failed to function as a pollen parent, it was used as a pistillate parent. As a female, it was easily hybridized with *S. phureja*, P.I. 225682 (formerly *S. rybinii*), a cultivated 24-chromosome species from South America. Several fruits were obtained, and each fruit contained a large number of seed. Therefore, even though the US-W3 haploid is only slightly pollen-fertile, it is highly functional as a female parent.

The finding of fertility in haploids of the common potato makes their use as future research material appear extremely promising. Genetic studies at the diploid level should now be possible with such materials. The success of this approach would overcome many of the problems inherent in genetic studies at

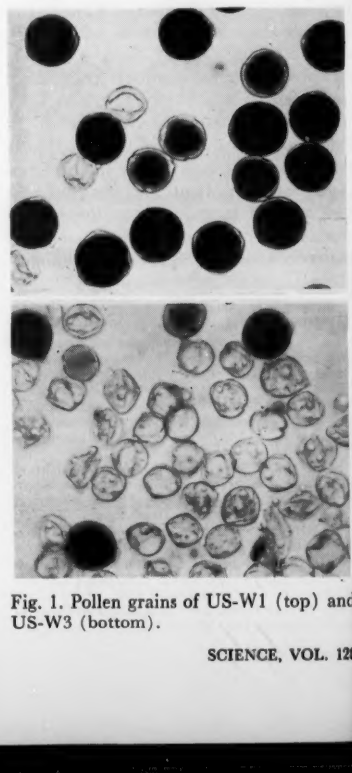

Fig. 1. Pollen grains of US-W1 (top) and US-W3 (bottom).

the tetraploid level. The haploids would seem to provide an excellent opportunity for effecting gene transfer from the numerous cultivated and wild diploid ($2n = 24$) *Solanum* species. They also represent promising material for studies on the nature of ploidy in *S. tuberosum* and chromosome differentiation within the tuber-bearing solanums.

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References and Notes

1. R. W. Hougas and S. J. Peloquin, *Nature* 180, 1209 (1957); R. W. Hougas, S. J. Peloquin, R. W. Ross, *J. Heredity* 49, 103 (1958).
2. This work was done in cooperation with the Inter-Regional Potato Introduction (IR-1) Project.
3. H. C. Choudhuri, *Trans. Roy. Soc. Edinburgh* 61, 199 (1944); M. S. Swaminathan and H. W. Howard, *Bibliographia Genet.* 16, 1 (1953).
4. J. G. Hawkes, *Scot. Plant Breeding Sta. Ann. Rept.* (1956), pp. 37–109.
5. E. V. Ivanovskaja, *Doklady Akad. Nauk. S.S.S.R.* 24, 517 (1939).

17 June 1958

Phosphorescence Spectra and Analyses of Some Indole Derivatives

Abstract. Phosphorescence spectra of solutions frozen and at low temperatures (77°K) possess more characteristic structure and detail than fluorescence spectra. They contain no background due to scattering of the exciting radiation. Thus greater analytical specificity and sensitivity are obtained. Some indole derivatives indistinguishable by spectrofluorimetry are easily differentiated by spectrophosphorimetry.

The substitution (*1*) of two monochromators for the customary light filters in fluorimetry, one for selecting the wavelengths of light for excitation, the other for the analysis of the resulting fluorescence, has made fluorimetry a rather general method of analysis of high sensitivity. The modification in technique was appealed to in the beginning especially for analyses of indole derivatives, which are of importance in the study of the central nervous system. In this report (*2*) we discuss characteristics of the closely allied spectra of phosphorescence (*3*) and their applicability for analyses, again with reference to indole derivatives.

The apparatus employed for fluorescence may serve for phosphorescence also, but the sample instead of being mobile as in a fluid solution must be rigid as in a glass or a crystal. Both fluorescence and phosphorescence spectra are emitted simultaneously, partially superimposed on each other. The time intervals in which the intensities of the two types of radiation diminish to half their values differ by orders of magnitudes, a characteristic which may be utilized to separate them. Indeed, a rotating phosphoroscope (*3*) between the two monochromators disposed at right angles as in fluorimetry was adequate for isolating the phosphorescence with half-life of the order of 1 second.

The phosphoroscope consisted of a rotating vertical cylindrical drum having two vertical slits 180 deg apart. On the axis was the solution in a fused silica tube within a fused silica Dewar flask. The retardation was the time required for a slit facing the first monochromator to make one quarter turn and face the second. At a rotation of 3000 rev/min the phosphorescence registered arose 5 msec after its excitation. A consequence was the elimination of the principal back-ground present in fluorescence which arises from the radiation of the light source scattered by the first monochromator.

The intensity of fluorescence increased with reduction in temperature and after solidification of the solution phosphorescence appeared at the expense of fluorescence. When some indoles had been dissolved only in water and frozen, the phosphorescence at 77°K was extremely feeble, but the addition of almost any solute such as an electrolyte increased the intensity (*4*). It appears that imperfection in the ice lattice favors trapping of excited states or electrons, forming what may be regarded as momentary color centers, in the same way as, under x-irradiation, color centers in crystals are favored by lattice imperfections introduced by impurities or mechanical strain (*5*). Variation of luminescence with solvent was also investigated. Some nonaqueous solutions yielded higher intensities than did aqueous solutions. Solvents were chosen that formed transparent glasses at the low temperature in order to reduce scattering and thereby achieve more intense luminescence.

Figure 1 shows recordings (*6*) of the phosphorescence spectra of the following substances (*7*) in transparent glasses of methanol and ethanol in ratio of 9 : 1. Indole (curve I) and tryptophan (curve II) exhibit different patterns. However, the fluorescence spectra of these substances at room temperature consist of virtually the same bell-shaped form with the same single maximum (*1*) at 360 mμ. 5-Hydroxytryptamine (serotonin) (curve III) shows still a different pattern. At room temperature only one maximum appeared at 330 mμ. At the low temperatures, indications of structure are evident in flourescence but they are not so distinct as they are in phosphorescence.

Reserpine (not shown here) had an entirely different shape for its phosphorescent spectrum, a tall mound with two minor peaks at 450 and 470 mμ. Indoleacetic acid and tryptamine, also indistinguishable from indole and tryptophan at room temperature, could be differentiated from them and from each other by means of their phosphorescence spectra, which resembled the spectrum of tryptophan rather closely. Greater differences in relative maxima were shown by indoleacetic acid than by tryptamine.

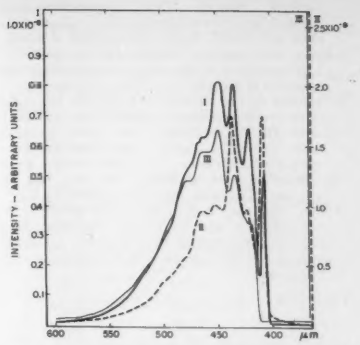

Fig. 1. Phosphorescence spectra of indole derivatives in alcohols at 77°K. I, Indole (2.5 mg/ml); II, tryptophan (0.5 mg/ml); III, 5-hydroxytryptamine (serotonin) creatinine sulfate (0.1 mg/ml) in glasses of methanol and ethanol, 9:1 by volume. Ordinates are in amperes.

In activation spectra different wavelengths produced phosphorescence spectra of different shapes as well as intensities. Such behavior furnishes highly specific criteria for identification.

We defer discussion of sensitivity to some later date. With our present equipment the sensitivity by phosphorescence was about 10 times as great as by fluorescence in the submicrogram region. The limitation appears as background due to the phosphorescence of solvents and of fused silica of containers. However, the phosphorescence contained no background due to scattered exciting radiation, which is chiefly limiting in the sensitivity of measurements by fluorescence.

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References and Notes

1. R. L. Bowman, P. A. Caulfield, S. Udenfriend, *Science* 122, 32 (1955).
2. This research was performed under the auspices of the U.S. Atomic Energy Commission.
3. P. Pringsheim, *Fluorescence and Phosphorescence* (Interscience, New York, 1949).
4. R. H. Steele and A. Szent-Györgyi [*Proc. Natl. Acad. Sci. U.S.* 43, 477 (1957)] found that the addition of glucose to aqueous solutions increased the intensity of phosphorescence.
5. N. F. Mott and R. W. Gurney, *Electronic Processes in Ionic Crystals* (Clarendon, Oxford, 1948). Impurities in fused silica also increase the number of color centers produced by radiation from uranium reactors.

6. The apparatus consisted of mercury arc (BH6, General Electric Co.), monochromators (Bausch and Lomb Optical Co.), photomultiplier tube (6903, Radio Corporation of America), and recorder (Brown Instrument Co.). The activation of the phosphorescence spectra consisted of a region from 280 to 310 mμ.
7. Sources of our materials: Serotonin was used as serotonin creatinine sulfate kindly furnished us by Dr. K. E. Hamlin, Jr., Abbott Laboratories, North Chicago, Ill., and by Sandoz Pharmaceuticals, Hanover, N.J. Both sources gave identical spectra. Reserpine was furnished by Mr. Louis Dorfman, Ciba Pharmaceutical Products, Summit, N.J. Indole was purified by crystallization and by several successive sublimations. Tryptamine hydrochloride, L(-)tryptophan, and indoleacetic acid, Eastman Organic Chemicals.

8 July 1958

Effect of Post Partum Separation of Mother and Kid on Maternal Care in the Domestic Goat

Abstract. Twenty-four goat mothers were separated from their newborn kids for 1 hour immediately following birth. Two months later these mothers were observed to nurse their own kids less and alien kids more than nonseparated mothers. Separation of mother and young in half the flock also resulted in abnormal "rejecting" behavior in some nonseparated mothers.

Recent studies (*1*) have demonstrated that the appearance of some types of normal, species-typical maternal behavior, often classed as "instinctive," is dependent upon the occurrence of specific experiences during critical periods in the life of the individual animal. Experimental or accidental changes in the "natural" environment at these times often result in the development of decidedly abnormal, species-atypical behavior.

Domestic sheep and goats normally rear their young within an individual-specific family structure. The suckling relationship between mother and young is typically limited to a particular parent and her offspring, and any attempt by a lamb or kid to nurse, or sometimes even to approach, a mother not its own results in that mother's withdrawal from and often violent repulsion of the alien offspring.

Descriptions of sheep and goat parturition indicate that the experience of the mother immediately following birth is critical to the development of this individual-specific infant-rearing pattern. Separation of mother and newborn for a short time at birth results in at least the temporary rejection of the young by the mother when mother and offspring are reunited (*2*).

Some observations of the behavior of separated mothers, however, suggest that maternal behavior often is unstable. Separated mothers who at first reject their own or foster young may occasionally later accept them, and mothers who at first accept young sometimes later reject them (*2, 3*). The study described in this report was undertaken to investigate the long-term, general effects of early mother-young separation on the individual mother and on the population as a whole.

Twenty-four domestic goat mothers were separated from their newborn kids for periods ranging from ½ hour to 1 hour, 5 to 10 minutes immediately following birth. The kids were permitted, or helped, to nurse their own mothers when mother and kid were reunited. A control group of 21 mothers, equated for age and parity, were allowed to follow the normal newborn care-taking pattern. The usual life of the flock was not specifically interfered with further until approximately 2 months (Table 1, observation 1) and, again, 3 months (Table 1, observation 2) after birth, when mother-kid interaction was studied in the following manner.

All the kids in the flock were housed in a room apart from all the adult goats for from 6 to 10 hours. The kids were deprived of both food and water during this time; the mothers received food and water as usual. Three of the kids, of approximately the same age, were then brought into the experimental room. One minute later the mother of one of the three kids joined them, and all four were observed for 15 minutes through a one-way-vision glass. An observer recorded the time in seconds of the mother's nursing and butting behaviors by activating separate electric clocks for the duration of each type of behavior as it occurred. This procedure was repeated until each mother had been observed with her kid and two others.

In each instance, the three kids appeared highly excited and fearful when they were first brought into the unfamiliar room. With the appearance of the mother, all three kids rushed toward her and attempted to nurse. The immediate reaction of all the mothers was to back away from this onslaught for the first 30 seconds. After this initial period, most nonseparated (control) mothers began the process of establishing a private territory for herself and her own offspring, by butting away the two other kids each time they approached her. After several minutes of being butted the other kids kept their distances, while the mother nursed her own kid in the usual manner.

In contrast, the separated (experimental) mothers behaved in a distinctly abnormal manner during both observation periods (Table 1), nursing their own kids less than the nonseparated mothers ($p = 0.01$) and nursing other kids more ($p = 0.01$). Separated mothers nursed other kids as long as they nursed their own, whereas nonseparated mothers nursed other kids relatively little, as compared with the time spent nursing their own ($p = 0.01$) (mean differences were tested for significance by t tests, which were computed separately for each observation period).

All butting behavior for both groups was normal; none of the mothers butted their own kids, although they butted other kids frequently.

An unexpected result of the study was the appearance of "rejecting" behavior (nursing neither their own nor other kids) among the mothers of the nonseparated group. Similar experimental analysis of the *post partum* behavior of another herd in which none of the kids had been separated at birth revealed no instances of "rejecting" behavior or of "indiscriminate" behavior (nursing other kids as long as, or longer than, their own), suggesting that the act of separating half the kids in the experimental herd had probably been the principal factor affecting maternal-young relationships of the nonseparated "rejecting" mothers. Although the specific cause of this effect on the nonseparated mothers is unknown, the "rejecting" behavior of the nonseparated mothers may have developed because their own kids wandered off shortly after birth and were

Table 1. Mean duration, in seconds, of maternal activities occurring during the 15-minute observation periods.

Condition	Separated mothers ($N = 24$)		Nonseparated mothers ($N = 21$)	
	Observation 1	Observation 2	Observation 1	Observation 2
Nursing own kids				
Mean	36.2	23.2	50.4	61.8
Standard deviation	11.4	9.7	16.5	22.3
Nursing other kids				
Mean	37.2	27.6	7.1	10.5
Standard deviation	9.3	10.1	6.8	8.8
Butting own kids				
Mean	0.0	0.0	0.0	0.0
Standard deviation	0.0	0.0	0.0	0.0
Butting other kids				
Mean	16.1	14.8	19.3	13.9
Standard deviation	15.3	12.6	15.7	10.0

accepted by the separated-"indiscriminate" mothers, since both separated and nonseparated mothers were kept together as one flock except for the short period during which the experimental mothers were separated from their young. Separation of some of these highly gregarious animals had thus influenced the social structure of the herd as a whole, changing the behavior of "control" animals whose early *post partum* experiences had not deliberately been disrupted, but whose environment had been affected in turn by abnormal maternal and filial behavior produced in the experimental members of their group (*4*).

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References and Notes

1. D. S. Lehrman, *J. Comp. and Physiol. Psychol.* 51, 32 (1958); H. G. Birch, *Am. J. Orthopsychiat.* 26, 279 (1956); B. F. Riess, *Ann. N.Y. Acad. Sci.* 51, 1093 (1950); F. A. Beach, in S. S. Stevens, *Handbook of Experimental Psychology* (Wiley, New York, 1951), p. 387.
2. N. E. Collias, *Ecology* 37, 228 (1956).
3. H. Blauvelt, in *Group Processes*, B. Schaffner, Ed. (1955), p. 221.
4. This study was conducted at the Behavior Farm Laboratory of Cornell University and was supported in part by grants from the Josiah Macy, Jr. Foundation and the Ford Foundation. We thank Dr. Howard Liddell, director of the laboratory, and Dr. Helen Blauvelt for advice and aid in planning and in carrying out this study.

7 July 1958

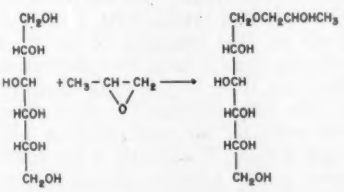
Rigid Urethane Foams Based on Sorbitol Derivatives

Abstract. Present commercial rigid foams are based on polyester raw materials. It has now been demonstrated that certain hydroxyl-terminated polyethers can be used satisfactorily as a major component of rigid urethane foams. These polyethers are hexafunctional materials prepared by reacting propylene oxide with sorbitol.

Commercial rigid urethane foams are prepared at present by reacting a suitable hydroxyl-terminated polyester with tolylene diisocyanate, water, and catalyst. Foaming commences, and the resulting foam is cured under the proper conditions.

Polyesters have been employed in such rigid foam preparations because of their multiple functionality and cross-linking potential. The multiple functionality is ordinarily obtained by the incorporation of glycerol in the polyester, with a branch or side chain arising at each glycerol molecule in the backbone of the polyester chain. In this way, by regulating the glycerol content, it is possible to obtain polyesters of high, moderate, and low degrees of branching. Generally speaking, polyesters used in rigid foams are highly branched, those in flexible foams are unbranched, and those employed in semirigid foams are moderately branched.

By contrast, at the present time, essentially no commercial rigid foams are based on polyethers. It has recently been demonstrated in this laboratory that certain highly functional hydroxyl-terminated polyethers can be used as a major component of rigid urethane foams. These hexafunctional polyethers are prepared by reacting propylene oxide with sorbitol. The addition of the first molecule of propylene oxide to sorbitol can be visualized as follows:



The reaction is carried out at elevated temperature and pressure in the presence of a suitable catalyst. More and more molecules of propylene oxide can be added until there are long chains of proplyene oxide extending from the sites of the original hydroxyl groups of the sorbitol molecule. The initial attack is most heavy on the primary hydroxyls, but after all hydroxyls become secondary the probability of attack at each hydroxyl is perhaps roughly equal to the probability at any other hydroxyl. The final product can be described as a hexafunctional molecule bearing six secondary hydroxyl groups of approximately equal reactivity toward isocyanate. Such products have been prepared with propylene oxide/sorbitol mole ratios of 10/1, 20/1, 40/1, and 80/1. These are pale to colorless free-flowing liquids that are soluble in a variety of solvents.

The molecular weights and approximate hydroxyl numbers of these materials are shown in Table 1.

The compounds of smaller molecular weight have higher hydroxyl numbers and will consequently produce higher concentrations of cross-links in the resulting urethane polymer formed by reaction with tolylene diisocyanate. On the other hand, propylene oxide/sorbitol in the mole ratio of 80/1 produces a much lower concentration of cross-links per unit of mass, and hence might well find use at a suitable concentration in semi-

Table 1. Molecular weights and approximate hydroxyl numbers of products prepared with propylene oxide/sorbitol in various mole ratios. The hydroxyl number is defined as milligrams of potassium hydroxide equivalent to the hydroxyl groups present in 1 gram of compound.

Mole ratio of propylene oxide/ sorbitol	Molecular weight	Hydroxyl number
10/1	760	440
20/1	1340	250
40/1	2500	130
80/1	4830	70

rigid and flexible foams, as well as in rigid foams.

Several of the materials listed in Table 1 have now been used to prepare rigid urethane foams by techniques that are widely known. For example, a foam was formulated from 300 parts (by weight) of 10/1 propylene oxide/sorbitol, 246 parts of tolylene diisocyanate (80/20 isomer ratio), 6.0 parts of water, 1.5 parts of silicone oil, and 0.3 parts of alkaline catalyst. After foaming was substantially complete, the foam was cured for 3 hours at 100°C. The rigid foam produced was white and had a fairly uniform cell size. It had a density of 4.1 lb/ft.^{3} Its compressive strength was 47.8 lb/in.^{2} at 25 percent compression, and 60.1 lb/in.^{2} at 50 percent compression.

The unique property of these new polyether foam ingredients is their high functionality, which causes them to approach the polyesters in cross-linking efficiency. It may also be noted that foams based on polypropylene oxide/sorbitol contain no ester linkages and hence may be more resistant to hydrolytic degradation by dilute acids and alkalis. The high functionality of polypropylene oxide/sorbitol compounds also makes them potentially valuable ingredients in polyurethane coatings and adhesives. One laboratory (*1*) has already observed that the incorporation of sorbitol itself in castor oil/tolylene diisocyanate coatings results in increased coating hardness, speed of cure, tensile strength, and solvent resistance.

This research is being extended at present to an investigation of the incorporation of propylene oxide derivatives of other hexitols in polyurethane foams and coatings.

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Reference

1. "Polyol–Modified Castor Oil–Nacconate 80 Coatings" (National Aniline Division of Allied Chemical and Dye Corporation, 1958).

24 June 1958

Cold Exposure and Heat Reinforced Operant Behavior

Abstract. Six rats, working in a 2°C ambient temperature, were trained to depress a lever to receive a brief period of heat. Four rats were then moved into the 2°C environment to live, while the others continued to live at room temperature. Living at a temperature of 2°C increased the number of heat presentations the animals delivered to themselves.

This report provides a brief description of an experiment (*1*) on the use of a behavioral index of the effects of cold exposure. In a variation of the operant conditioning setup (see *2*), brief periods of heat were delivered to cold-exposed rats, rather than food or water to deprived ones, as reinforcement for the response of depressing a small lever (*3*).

The establishment of stable lever-pressing behavior can be divided into three phases. In the first, the animals (adult, male, Sprague-Dawley rats) were placed in a small response chamber, at an ambient temperature of about 2°C, for 1 hr. Throughout the session 10-sec periods of heat (about a 15°C rise) were presented at the rate of two per minute. The response chamber was heated by the application of voltage to heating coils mounted just below the hardware-cloth floor. A continuous, slow-speed fan below the coils accelerated the passage of heated air into the chamber during the 10-sec "heat time" and cooled it at the end of this period. Throughout each period of heat presentation, a tone of intermediate frequency and moderate intensity was also delivered. The apparatus was housed in a larger refrigerated room maintained at approximately 2°C. The fully automatic control and recording devices were housed in a separate room.

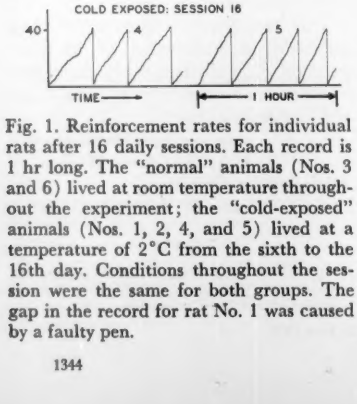

Fig. 1. Reinforcement rates for individual rats after 16 daily sessions. Each record is 1 hr long. The "normal" animals (Nos. 3 and 6) lived at room temperature throughout the experiment; the "cold-exposed" animals (Nos. 1, 2, 4, and 5) lived at a temperature of 2°C from the sixth to the 16th day. Conditions throughout the session were the same for both groups. The gap in the record for rat No. 1 was caused by a faulty pen.

At the end of the 1-hr session, the rat was returned to its cage in the colony room, maintained at about 20°C, where the animal had continuous access to food and water.

The second phase of training began the next day. A T-shaped lever, parallel to the floor and 2 in. above it, had been inserted into the chamber. During this 1-hr session, depressing the lever produced the 10 sec of heat and tone. We found that, unless some such stimulus as the tone was paired with each heat presentation, stable lever pressing could not be established. Depressions made *during* the 10-sec "heat time" had no effect on the duration of the current presentation or on the presentation of subsequent heat periods.

The third daily 1-hr session was divided into two half-hour segments. The conditions of the first half-hour were identical to those of the second session. The speaker that delivered the tone was then disconnected. From this point on (the beginning of the third training phase), each lever depression delivered 10 sec of heat unaccompanied by any other stimulus. The third phase was continued for three additional 1-hr daily sessions. The details of the apparatus and of a similar procedure have been presented elsewhere (*4*).

We have used the behavior so generated as an index of the effects of prolonged exposure to cold. Because we were primarily concerned with changes in the way in which the animal "heated itself," our basic datum was the rate at which reinforcements were delivered rather than the response rate. These two measures are not identical, since the animal could, and did, respond during any 10-sec period of heat presentation—that is, response rate was greater than reinforcement rate. The reinforcements were plotted by a cumulative recorder. The pen reset to the base line after 40 reinforcements.

Following the sixth daily session, four randomly selected animals (Nos. 1, 2, 4, and 5) were moved into an ambient temperature of 2°C, while two others (Nos. 3 and 6) continued to live at room temperature. The daily 1-hr lever-pressing sessions were continued as usual. In session 6, the average reinforcement rate for rats No. 1, 2, 4, and 5 was 0.58 reinforcements per minute; for rats No. 3 and 6 it was 1.03 per minute.

The data shown in Fig. 1 are for session 16, 10 days after the exposed animals began to live in the cold. It will be seen that all animals "deliver" heat to themselves at a roughly constant rate throughout the session; this is apparent in the over-all linearity of the records. It is also clear that the reinforcement rates for the cold-exposed animals are markedly higher, in all cases, than are those for the control animals. The average reinforcement rate for the exposed animals is 2.8 reinforcements per minute; for the control animals it is 1.7. Relative to their performance in session 6, then, the average rate for the exposed animals increased by about 2.2 reinforcements per minute, while that for the controls increased by 0.7 per minute.

The session-to-session course of this rise in reinforcement rate for other rats, as well as the relationships among reinforcement rate, body weight, and food consumption, has been reported elsewhere (*5*).

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References and Notes

1. The experiment was conducted at the U.S. Army Medical Research Laboratory, Fort Knox, Ky. The opinions expressed are entirely ours and do not necessarily reflect those of the Office of the Surgeon General or the Department of the Army.
2. B. F. Skinner, *The Behavior of Organisms* (Appleton-Century-Crofts, New York, 1938).
3. A similar procedure, in which a different means of heat delivery was used, has been described by B. Weiss ["Thermal behavior of the subnourished and pantothenic-acid-deprived rat," *J. Comp. Physiol. Psychol.* 50, 481 (1957)].
4. P. L. Carlton and R. A. Marks, *USAMRL Rept. No. 299, Fort Knox, Ky.* (1957).
5. ———, *USAMRL Rept. No. 325, Fort Knox, Ky.* (1957).

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10 July 1958

Influence of Hexane Solubles in Tobacco on a Polycyclic Fraction of Cigarette Smoke

Abstract. No variation in total amounts of those polycyclic hydrocarbons with ultraviolet absorption maxima at 385 mμ was found in the smoke from cigarettes containing varying amounts of hexane solubles. Addition of C^{14}-labeled tobacco paraffins to cigarettes showed that tobacco paraffins are unimportant as precursors of polycyclic hydrocarbons in smoke.

Removal of waxes from tobacco by a "dry cleaning" or extraction with a low-boiling solvent such as hexane has been suggested as a means of reducing the amounts of polycyclic hydrocarbons in cigarette smoke. Lam (*1*) demonstrated the formation of polycyclic hydrocarbons on pyrolysis of tobacco paraffins at temperatures higher than 600°C. Campbell and Lindsey (*2*) reported that extraction of cigarettes with cyclohexane reduced the amounts of polycyclic hydrocarbons by more than 50 percent, but they obtained similar results on extraction of paper cigarettes, and paper contains little or no material soluble in cyclohexane. Gilbert and Lindsey (*3*)

found that polycyclic hydrocarbons are formed on pyrolysis of cellulose, lignin, pectin, starch, sucrose, glucose, and fructose and of citric, malic, and oxalic acids. These compounds, which total up to more than 50 percent of the weight of flue-cured cigarette tobacco, are insoluble in hexane and are not volatile. Compounds which are volatile without decomposition, such as the paraffins and many other compounds present in the hexane extract of tobacco, may be volatilized and transmitted unchanged to the mainstream smoke.

Several experiments were performed (*4*) to obtain some information on the contribution of the hexane-soluble material of tobacco, especially paraffins, to the polycyclic hydrocarbons in cigarette smoke. Estimations were made only on the basis of the height of a peak at 385 mμ in the ultraviolet spectra of fractions obtained by chromatographic separation of the neutral, benzene-soluble portion of the smoke. For each determination 200 cigarettes 70 mm in length were smoked; an automatic smoking machine was used, which took one 35-cm^3 puff of 2-second duration per minute until two-thirds of the cigarette was consumed. The smoke was collected by gravity deposition at room temperature and was extracted with benzene. After removal of bases and acids by extraction with dilute acid and alkali, the solution was concentrated and separated on columns of aluminum oxide, silica gel, and silicic acid. Development of the columns was accomplished by means of cyclohexane containing increasing amounts of benzene. The eluate was collected in small fractions, and the ultraviolet spectra of fractions taken at regular intervals was determined with a Beckman DR recording spectrophotometer. Those fractions showing evidence of peaks at 363 and 385 mμ were combined and evaporated, and the residue was separated on the next column. Estimations were made on the eluate from the last column by a base-line technique, as described by Cooper (*5*).

Variations in the relative size and position of the peaks and in the rate of elution from the last column indicated that a mixture of compounds was present which had absorption peaks at or near 385 mμ. Further separation of this fraction by other methods showed the presence of at least four compounds. The results are therefore a measure of the total polycyclic hydrocarbons of similar ultraviolet spectra which are present in this fraction but are not a true measure of the amounts of any one compound.

Estimations made on the smoke from blended cigarettes gave values of about 0.05 μg per cigarette, with a variation between duplicate determinations of about ±5 percent. The addition of known amounts of 3,4-benzpyrene of this magnitude to the smoke, followed by separation and estimation of the polycyclics in this fraction, resulted in an increase in the estimates of the amounts present of from 85 to 100 percent of the amounts added.

Table 1. Analyses of cigarette tobacco and smoke.

Sample	Tobacco		Smoke	
	Paraffins (%)	Hexane extractives (%)	Total solids (mg per cigarette)	Polycyclics (μg per cigarette)
Control	0.37	5.44	39.3	0.07_4
Soxhlet-extracted	0.00	0.00	30.8	0.06_7
Percolated	0.06	2.34	32.1	0.06_7
Paraffins added	0.57	5.63	41.2	0.07_1
Hexane extractives added	0.69	9.06	45.9	0.07_7

The results obtained by analysis of the smoke from cigarettes containing varying amounts of paraffins and hexane extractives are shown in Table 1. The control cigarettes were made from a blend of commercial grades of flue-cured (Bright) tobaccos. Cigarettes were made from the same blend after extraction with hexane in a Soxhlet apparatus and after percolation with hexane at room temperature. The other samples show the effect of the addition of more tobacco paraffins and concentrated hexane extract of the same blend of tobacco. Total particulate material in the mainstream smoke, reported as total solids, was determined by drawing the smoke through a tared glass filter disk (Cambridge CM No. 113) and finding the increase in weight. The increase in this value with increasing amounts of hexane-soluble material in the tobacco was quite pronounced and supports the view that many of the hexane-soluble compounds are transferred to the mainstream smoke before they are heated sufficiently to cause extensive decomposition. Variations in the estimated amounts of polycyclic hydrocarbons were so small that they were probably due to experimental errors. Thus, the value found for the cigarettes with paraffins added was intermediate between the values obtained for the controls and those found for the extracted cigarettes, differing from each by about 5 percent. The results indicate that hexane extraction of tobacco would reduce the polycyclics in the smoke by amounts so slight as to be undetectable by these methods.

The use of radioactive tracer techniques offered a method of greater sensitivity for the determination of the contribution of the tobacco paraffins to the formation of polycyclics. Randomly labeled tobacco paraffins were isolated from tobacco grown in an atmosphere of $C^{14}O_2$ at the Nutriculture Laboratory of the Medical College of Virginia. By means of a hypodermic syringe, a hexane solution of 131.2 mg of these paraffins was injected into 200 of the control cigarettes; the solution was injected only into the two-thirds of each cigarette which was to be smoked. After aeration to remove the hexane, the cigarettes were smoked, and both main- and sidestream particulate material was collected. The butts were extracted with cyclohexane, and the same polycyclic fraction was obtained from this solution and from the main- and sidestream smoke by the methods used with the previous samples. The paraffins were also recovered, and the radioactivity was determined in the paraffin and polycyclic fractions. Of the 74.84 μc added, 52.34 μc, or 70 percent, was recovered as unchanged paraffins. The mainstream polycyclic fraction contained only 0.0000127 μc, equivalent to 0.022 μg of the 131.2 mg of radioactive paraffins added to 200 cigarettes. On the assumption that the nonradioactive paraffins in a cigarette behave in the same way, it may be concluded that the 2.2 mg present in two-thirds of a control cigarette would contribute only 0.0004 μg to these polycyclic hydrocarbons. This would be only 1/180 of that derived from other sources and demonstrates that no significant reduction of polycyclic hydrocarbons in cigarette smoke would result from the removal of the paraffins by hexane extraction of the tobacco (*6*).

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References and Notes

1. J. Lam, *Acta Pathol. Microbiol. Scand.* 37, 421 (1955).
2. J. M. Campbell and A. J. Lindsey, *Brit. J. Cancer* 10, 649 (1956).
3. J. A. S. Gilbert and A. J. Lindsey, *ibid.* 11, 398 (1957).
4. Grateful acknowledgment is extended to Mrs. Thelma Monbarren, R. N. Gladding, and R. C. Bateman for their assistance in various phases of these investigations.
5. R. L. Cooper, *Analyst* 79, 573 (1954).
6. This report was presented at the 133rd national meeting of the American Chemical Society, Agriculture and Food Division, San Francisco, 15 Apr. 1958.

3 July 1958

Dichromography—a Method for in vivo Quantitative Analysis of Certain Elements

Abstract. The method is based on absorption measurements of monochromatic x-rays. The radiation dose given to the patient is low, and thus the method is nondestructive. The physiological content of iodine in the human thyroid can be determined, as well as the distribution in the body of small amounts of roentgenological contrast substances.

A nondestructive method for the quantitative analysis of elements inside a living person would be of value for determining the function of organs in diagnostic and physiological studies. The use of monochromatic x-rays makes it possible to determine certain heavy elements as well as ensuring an optimum amount of contrast per dose given to the patient when producing radiographic images.

Any one element can be quantitatively determined according to the Beer law by measuring the attenuation of one monochromatic x-ray beam (*1*). Similarly, two elements can be analyzed with two monochromatic rays, provided that the ratios of the mass absorption coefficients of the elements are sufficiently different at the two wavelengths. To the first approximation the human body is composed of soft tissue, bone salt, and iodine (normally present in the thyroid or otherwise employed as a roentgenological contrast medium). If bone structures are avoided, two wavelengths are therefore sufficient for an in vivo analysis of the amount of iodine and soft tissue in a body section. Preferably the two wavelengths are chosen on each side of the absorption edge of iodine at 0.37 A (*2*).

The equipment comprises an x-ray tube for the production of monochromatic radiation through secondary emission, a system composed of two servo-controlled absorption wedges, a scintillator photomultiplier unit sensing the x-ray intensity, and an electronic feedback loop from the mutliplier to the two servomotors (*3*). One wedge is composed of material equivalent to soft tissue (for example, water); the other, of iodine. The two wedges are automatically kept in such a position that the intensities at the scintillator are constant. When the patient is placed in the beam, the two wedges are withdrawn a certain distance corresponding to the amount of soft tissue and iodine in the patient. Thus, the displacements of the two wedges are quantitative measures of the amounts of these substances. A scanning process is employed when producing images, showing the quantitative distribution.

At present the accuracy of the method is within ± 0.2 mg of iodine per square centimeter for static measurements and ± 0.5 mg/cm² when scanning is employed at a rate of 0.5 cm/sec and with a beam cross section of 0.25 cm². The accuracy is limited by statistical fluctuations of the number of quanta in the x-ray beam and by photomultiplier drift. Another error not included in the values given is caused by the presence of fat in the tissues. Fat has an absorption characteristic slightly different from that of the soft tissue wedge (water). Thus, 1 g of fat per square centimeter simulates the presence of 0.5 mg of iodine per square centimeter.

An additional advantage of the soft-tissue wedge is that the dose given to the patient is at a theoretical minimum. The beam is constantly attenuated so as to allow no more quanta to pass the patient than those necessary for the desired statistical accuracy. During a typical investigation of the thyroid, the dose becomes less than 1 mr.

The iodine distribution in a normal thyroid can be seen in Fig. 1. Each plotted curve represents the mean value of the ink recordings of two adjacent scanning lines. Deviations on the base level, representing the zero iodine values, are due to statistical fluctuations in the beam. It should be noted that no iodine, stable or radioactive, has been given to the patient before the investigation. The method is thus entirely different from that employed in radioiodine thyroid function tests.

The method has also been used for function tests of the liver, kidneys, and lungs, or of localized parts of these organs, in human beings and other animals, performed by studying the amount of iodine present in the organs after intravenous injections of contrast substances containing iodine (*4*). Circulation tests are also possible, as is the determination of the amount of blood in certain parts of the body.

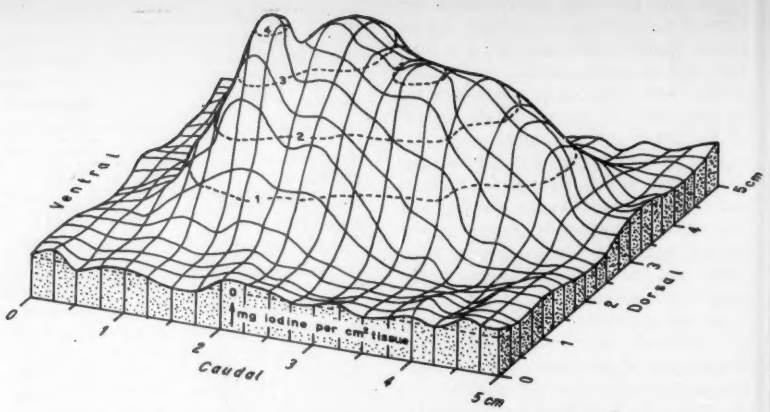

Fig. 1. Stereogram showing the distribution of iodine in a normal human thyroid. The peak concentration of 4 mg of I per square centimeter in the caudoventral part corresponds to the thyroid isthmus. The total amount of iodine in this thyroid was 23.5 mg. No iodine had been given to the patient prior to the determination.

Preliminary experiments indicate the possibility of measuring the amount of bone salt simultaneously with determination of the iodine and soft-tissue values by means of three selected wavelengths and three wedges (*5*).

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References and Notes

1. For a review of such methods, see A. Engström, in *Physical Techniques in Biological Research*, G. Oster and A. W. Pollister, Eds. (Academic Press, New York, 1956), vol. 3, p. 489.
2. B. Jacobson, *Acta Radiol.* 39, 437 (1953).
3. ——— and R. S. Mackay, in *Advances in Biological and Medical Physics*, J. H. Lawrence and C. A. Tobias, Eds. (Academic Press, New York, in press), vol. 6.
4. A report on these tests, written in cooperation with P. Edholm, is in preparation.
5. The method described has been developed during the last three years by means of financial support from Knut och Alice Wallenbergs Stiftelse and from Harald och Greta Jeanssons Stiftelse.

16 June 1958

Effect of Growth Hormone on Lipid Aldehydes

Abstract. Female rats at the body weight plateau which responded to 13 daily injections of 0.4 mg of growth hormone by greater weight gain per gram of food had a decreased concentration of lipid aldehydes in blood plasma, an increased concentration in liver, and no change in intestine, compared with control rats given isotonic saline.

The administration of growth hormone (GH) decreases the rate of turnover of plasma phospholipids in man (*1*) and increases the content and the rate of turnover of the phospholipids of the liver

in the rat (*2*). The response of individual phospholipids to the hormone has not been demonstrated. The data presented here (*3*) indicate that the administration of growth hormone to the rat changed the lipid aldehyde concentration (plasmalogen) of the liver and blood plasma.

Twenty-six female Sprague-Dawley rats that had reached a body weight plateau were divided into two equal groups, and the food consumption of each rat was measured. One group received 13 daily intraperitoneal injections of 0.2 ml of a solution containing 2 mg/ml of Somar (Armour somatotropin) (*4*); the other received daily injections of 0.2 ml of sterile isotonic saline. By the 14th day, when the experiment was terminated, the rats that had been injected with growth hormone had gained an average of 115 mg body weight per gram of food, compared with 41 mg per gram for the controls ($p < .001$) (*5*).

The rats were killed by decapitation, and the blood was collected in citrate. The liver was removed, weighed, frozen, lyophile-dried, and ground. The whole intestine was removed, washed out, frozen and lyophile-dried. After centrifugation, a 2 ml portion of the blood plasma was introduced drop by drop into a solution of 95-percent ethyl alcohol–diethyl ether (3:1); the solution was allowed to stand at room temperature overnight, then raised to boiling, cooled, and made to volume; and the protein precipitate removed. An aliquot portion of the lipid extract was evaporated to dryness; the residue was treated with acetic acid and mercuric chloride followed by Schiff's reagent (*6*). The color was extracted with chloroform and read against a standard prepared in the same way or from a calibration curve, to obtain milligrams of stearaldehyde.

One gram of dry liver (or the whole dry intestine) was treated overnight with the alcohol-ether solution; the mixture was then heated to boiling, and the insoluble residue was centrifuged off and reextracted with the hot solvent. The combined extracts were evaporated to dryness, the lipid was extracted from the residue with petroleum ether–chloroform (5:1), and the extract was washed with an equal volume of 50-percent ethyl alcohol. After removal of the solvent the total lipid was dried, weighed, and redissolved in chloroform.

In order to estimate the amount of fat in the liver, values for phospholipid and cholesterol were determined in this total lipid extract. Phospholipid was precipitated by acetone and weighted; cholesterol was determined by the Liebermann-Burchard reaction. The difference between the sum of the values for the separately determined lipids and the total lipid fraction was designated as "fat."

Table 1. Lipid aldehyde concentration of blood plasma, liver, and intestine of normal rats and of rats injected with growth hormone (GH). The number of determinations is given in parentheses.

	Normal		GH		p values
	Av.	S.D.*	Av.	S.D.*	
Blood plasma (mg %)	3.10(11)	1.01	1.35(12)	0.52	< 0.001
Liver (dry tissue, %)	0.33(13)	0.06	0.43(12)	0.11	$< 0.02; > 0.01$
Intestine (dry tissue, %)	0.21(10)		0.23(12)		

* Standard deviation of the arithmetic mean (Av).

The acetone-insoluble and the acetone-soluble fractions were treated like the blood extract for development of color with the Schiff's reagent (*6*). The sum of the aldehyde of each fraction gave the total aldehyde of the dry tissue.

As is shown in Table 1, the administration of growth hormone decreased the lipid aldehyde concentration of the blood plasma, from a normal value of 3.10 to 1.35 mg percent aldehyde ($p < 0.001$). This decrease is more marked than that for the plasma phospholipid phosphorus of normal patients given growth hormone (*1*).

In the liver, growth hormone caused a significant increase in total aldehyde, not only in concentration but in the amount per total liver, since the liver-to-body-weight ratio was the same in the treated and untreated groups. The increase in total aldehyde of the tissue following administration of growth hormone may indicate a change in molecular type of the individual phospholipids from those containing both fatty acids in esterified linkage to those containing only one esterified acid plus a potential fatty acid aldehyde in ether linkage (*7*). Such a change may have resulted from a diminished supply of fatty acids. The decreased ability of the livers of GH-treated rats to synthesize fatty acids from either pyruvate or acetate has been shown (*8*). Our finding of only 1.1 percent "fat" in the livers of the GH-treated rats compared with 2.4 percent for the normal ($p < 0.05$; > 0.02), in the absence of any change in amounts of phospholipid or cholesterol, supports this explanation for the increased aldehyde content. A similar inverse relationship between total lipid (mainly fat) and plasmalogens has been found in the adipose tissue of the young rat (*9*).

In the intestines, unlike the liver, the lipid aldehyde concentration of the tissue did not change following treatment with growth hormone.

According to the recently proposed structure for plasmalogens (*7*), these contain an α,β-unsaturated ether linkage, which is capable of taking part in a wide variety of chemical reactions. The decrease in lipid aldehyde concentration of the blood following administration of growth hormone and the increase in the liver shown in this experiment seem to link the plasmalogens as aldehyde precursors with the action of this hormone.

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References and Notes

1. E. A. McCulloch, A. Britton, C. J. Bardawill, K. J. R. Wightman, *Science* 123, 1084 (1956).
2. A. L. Greenbaum and P. McLean, *Biochem. J.* 54, 407 (1953); A. L. Greenbaum, C. N. Graymore, T. F. Slater, *J. Endocrinol.* 15, 235 (1957).
3. This investigation was supported by research grant C669(C7) and fellowship CF-5936 from the National Cancer Institute, National Institutes of Health, U.S. Public Health Service; and by an American Cancer Society grant (Instr. 57E).
4. Countesy of Dr. Sanford L. Steelman, Armour Laboratories, Chicago, Ill.
5. C. H. Goulden, *Methods of Statistical Analysis* (Wiley, New York, 1939), p. 40; R. A. Fisher and F. Yates, *Statistical Tables for Biological, Agricultural and Medical Research* (Oliver and Boyd, London, 1938), p. 26.
6. W. F. Neuman, Ph.D. thesis, University of Rochester.
7. G. V. Marinetti, J. Erbland, E. Stotz, *J. Am. Chem. Soc.* 80, 1624 (1958); M. M. Rapport and R. E. Franzl, *J. Neurochem.* 1, 303 (1957).
8. A. L. Greenbaum and R. F. Glascock, *Biochem. J.* 67, 360 (1957).
9. C. L. Yarbro and C. E. Anderson, *Proc. Soc. Exptl. Biol. Med.* 91, 408 (1956).
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18 June 1958

Effect of Oxidation and Reduction upon the Biological Activity of Parathyroid Hormone

Abstract. Parathyroid hormone loses biological activity upon oxidation with hydrogen peroxide. Part or all of this lost activity can be regained by subsequent reduction with cysteine. The extent and reversibility of this oxidation is dependent upon *p*H.

During work upon the isolation of the calcium-mobilizing principle from bovine parathyroid glands, a frequent decrease or disappearance of hormonal activity has been observed. This has been particularly true when material that has been subjected to countercurrent distribution was assayed. Because many of the

Table 1. Biological activity of parathormone-B after oxidation and reduction.

Preparation	Initial potency* (U.S.P. units/mg)	*p*H† of oxidation	Potency after oxidation (% of initial)	Potency after reduction (% of initial)
PTH-B	150–200	3.8	40–65	110–180
PTH-B	160–200	4.8	35–60	110–140
PTH-B	160–200	7.0	5–20	40–70
Reagent control	0	3.8	0	0–10

* Determined on control solution (see text).
† The buffers employed were: 0.01*M* glycine acetate, *p*H 3.8; 0.06*M* sodium acetate – 0.01*M* glycine, *p*H 4.8; and 0.01*M* potassium phosphate, *p*H 7.0.

findings were closely analogous to those noted during the isolation of adrenocorticotropin (ACTH) (*1*), it seemed possible that parathyroid hormone might undergo oxidation and reduction, with accompanying loss and regain of biological activity, in a manner similar to that reported by Dedman *et al.* for ACTH. It has been known for some time (*2*) that parathyroid hormone activity is destroyed by oxidizing agents but not by reducing agents. There has never been any evidence reported, however, to indicate that the loss of activity brought about by oxidation could be regained subsequently by reduction.

Experiments have been undertaken, therefore, to see whether the effects of oxidation upon the biological activity of parathormone can be reversed by reduction. For these experiments, parathormone-B (PTH-B), prepared as previously described (*3*), was dissolved (1 mg/ml) in buffer solutions at *p*H 3.8, 4.8, or 7.0, respectively. As a control, an aliquot of the solution was removed for assay. A sufficient amount of 30-percent hydrogen peroxide was added to the remainder to make the solution 0.1*M*. The oxidation was allowed to proceed for 30 minutes at from 25° to 28°C, after which it was stopped by the addition of from 0.5 to 1.0 mg of catalase (*4*). The solutions were then brought to *p*H 3.8 by the addition of 0.1*M* acetic acid, and an aliquot was taken for biological assay. Cysteine hydrochloride (20 mg/ml) was added to the remaining solution, which was heated to 80°C in an oven and kept at this temperature for 6 hours. The solution stood for another 12 hours at 25°C before being assayed. A reagent control solution, containing no hormone, was carried through the same procedure and assayed at the same time. The control, the reagent control, peroxidized, and peroxidized-reduced preparations were then assayed for their calcium-mobilizing ability in parathyroidectomized rats by a modification of the method described by Munson (*5*). Young male rats weighing from 110 to 120 g were kept on a low calcium diet for 4 days before destruction of their parathyroids was carried out by electric cauterization. Immediately after operation they received an aliquot of the test solution, and 6 hours later a blood sample was obtained by cardiac puncture. The cardiac puncture, anesthesia, and calcium determinations were carried out as previously described (*6*). The results have been recorded in Table 1 as percentages of original potency, 100 percent being the response obtained with the control solution in each assay.

As can be seen in Table 1, parathormone-B loses biological activity upon oxidation and regains activity upon subsequent reduction. The loss of activity appears to be greater, and in part irreversible, when oxidation is carried out at the higher *p*H values. Sometimes the potency of the material treated with cysteine hydrochloride was significantly greater than that of the control. Also, it has been possible to reactivate by reduction a number of parathormone-B preparations which had spontaneously lost part (as high as from 25 to 70 percent) of their biological activity.

Since it seemed possible, but unlikely, that the large excess of cysteine employed caused reactivation by means other than reduction, attempts were made to produce a similar effect by adding equimolar amounts of NaCl (solution brought to *p*H 2.0 with HCl) or of glycine hydrochloride (*p*H 2.0) to the oxidized hormone. In neither instance was there recovery of the lost activity.

These results are quite similar to those obtained by Dedman *et al.* in their studies with ACTH (*1*). At present it is believed that ACTH contains no cystine or free sulfhydryl groups. The chemical groups involved in this unusual phenomenon remain to be elucidated. Similar properties have also been described for melanocyte-stimulating hormone (*7*), which also is thought to lack sulfhydryl groups and cystine. Amino acid analysis of a hydrochloric acid hydrolysate of a highly purified preparation of parathormone-B showed no significant amount of cystine (*8*). In addition, amperometric titration of parathormone-B in 8*M* urea, by the method of Benesch, Lardy, and Benesch (*9*), did not reveal any free sulfhydryl groups. Thus, the similarity between the oxidation-reduction properties of parathormone-B and those of the two pituitary hormones is quite striking.

The dependence of the biological activity of parathyroid hormone upon the state of oxidation or reduction has obvious practical implications for those engaged in work upon the isolation of parathyroid hormone. Whether it has any biological significance remains to be determined. However, it is interesting to note that a suggested mechanism for the action of both ACTH and parathormone involves a triphosphopyridine-nucleotide-linked oxidation-reduction system (*10*). It seems possible, therefore, that the unusual oxidation-reduction properties of these hormones may be of importance in their biological activity (*11*).

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References and Notes

1. M. L. Dedman, T. H. Farmer, C. J. O. R. Morris, *Biochem. J.* 66, 166 (1957).
2. W. R. Tweedy, W. R. Bell, C. Vincens-Rios, *J. Biol. Chem.* 108, 105 (1935).
3. H. Rasmussen, *ibid.* 229, 781 (1957).
4. The catalase used in this study was obtained from Nutritional Biochemicals Corp., Cleveland, Ohio.
5. P. L. Munson, *Ann. N.Y. Acad. Sci.* 60, 776 (1955).
6. H. Rasmussen and R. G. Westall, *Biochem. J.* 67, 658 (1957).
7. H. B. F. Dixon, *Biochim. et Biophys. Acta* 19, 392 (1956).
8. D. H. Spackman, W. H. Stein, S. Moore, *Anal. Chem.* 30, 1190 (1958). I wish to thank Dr. Spackman for carrying out these analyses.
9. R. E. Benesch, H. A. Lardy, R. Benesch, *J. Biol. Chem.* 216, 663 (1955). I wish to thank Dr. R. D. Cole for this determination.
10. W. H. Neuman, H. Firschein, P. S. Chen, Jr., B. J. Mulryan, V. Di Stefano, *J. Am. Chem. Soc.* 78, 3863 (1956); R. C. Haynes, Jr., and L. Berthet, *J. Biol. Chem.* 225, 115 (1957).
11. This work was supported, in part, by a grant (A-1953) from the National Institute for Arthritis and Metabolic Diseases, U.S. Public Health Service.

27 June 1958

Association Affairs

Programs Planned for the AAAS Washington, D.C., Meeting

Section and society programs in the medical sciences, (including dentistry and pharmacy), to be presented at the Washington meeting, are given here. Programs in mathematics, physics, chemistry, astronomy, geology and geography, the biological sciences, anthropology, psychology, the social and economic sciences, the history and philosophy of science, engineering, and agriculture have been previously announced.

Medical Sciences

Section N. Four-session symposium, endorsed by the American Heart Association and the American College of Cardiology: "Congenital Heart Disease"; arranged by Allan D. Bass, Vanderbilt University School of Medicine, and Gordon K. Moe, Upstate Medical Center, State University of New York; 29 and 30 Dec.

Part I: "Development of the Heart and the Origins of Congenital Heart Disease"; S. R. M. Reynolds, University of Illinois College of Medicine, presiding. Papers on developmental processes involved in cardiogenesis (Alexander Barry, University of Michigan Medical School), fetal circulatory homeostasis (S. R. M. Reynolds), fetal and neonatal circulation in relation to congenital heart disease (Geoffrey Dawes, Nuffield Institute for Medical Research, Oxford, England), fetal and neonatal circulation —observations in humans (Forrest H. Adams, University of California Medical Center), experimental production of congenital cardiac defects (James G. Wilson, University of Florida College of Medicine), etiologic factors in congenital heart disease (Josef Warkany, University of Cincinnati).

Part II: "The Pathologic Physiology of Congenital Heart Disease"; Lewis Dexter, Harvard Medical School, presiding. Papers on the pathologic anatomy of congenital intra- and extracardiac shunts (Maurice Lev, Hektoen Institute and Northwestern University Medical School), hemodynamic alterations associated with septal defects and aortic-pulmonary communications (Earl H. Wood, Mayo Clinic), the pathologic anatomy of congenital obstructive lesions and of pulmonary hypertension (Jesse E. Edwards, Mayo Clinic), the response of the heart to obstruction of ventricular outflow (S. Gilbert Blount, Jr., University of Colorado School of Medicine).

Part III: "The Diagnosis of Congenital Heart Disease"; André Cournand, Columbia University College of Physicians and Surgeons, presiding. Papers on cardiac catheterization techniques using pressure, flow, and oxygen analysis (Lewis Dexter), indicator-dilution techniques (Earl H. Wood), the characterization of circulatory shunts with foreign gas techniques (Eugene Braunwald, National Heart Institute), cinecardioangiography in the disease of congenital lesions (F. Mason Sones, Jr., Cleveland Clinic), intracardiac phonocardiography in the diagnosis of congenital heart disease (David Lewis, Philadelphia General Hospital), relative role of various clinical and hemodynamic techniques in diagnosis of congenital heart disease and in selection for surgery (Howard B. Burchell, Mayo Clinic).

Part IV: "Surgical Therapy of Congenital Heart Disease"; Alfred Blalock, Johns Hopkins University Medical School, presiding. Papers on the surgical treatment of pulmonary valvular stenosis and atrial septal defect using hypothermia (Henry Swan, University of Colorado Medical Center), surgical correction of septal defects and aneurysms of the sinus of Valsalva (C. Walton Lillehei, University of Minnesota Medical School), the surgical treatment of cyanotic congenital heart disease (John W. Kirklin, Mayo Clinic), problems of extracorporeal circulation (Robert Gross, Harvard Medical School), present status and future trends in the surgical therapy of congenital heart disease (Denton Cooley, Baylor University College of Medicine).

There will be two supplemental sessions on congenital heart disease in the form of closed-circuit color television programs, for professional people holding cards of admission.

Alpha Epsilon Delta National Premedical Honor Society. Symposium, cosponsored by AAAS sections C (Chemistry), F (Zoological Sciences), N (Medical Sciences), and Nd (Dentistry) and by Beta Beta Beta Biological Society and George Washington University School of Medicine: "Premedical and Predental Education"; 27 Dec.; Lloyd R. Gribble, West Virginia University, presiding. Welcome by O. C. Colclugh, George Washington University, and introductory remarks by Lloyd R. Gribble. Papers on the student in medicine (John Parks, George Washington University School of Medicine), the Johns Hopkins University Plan for Medical Education (Samuel P. Asper, Jr., Johns Hopkins University School of Medicine), the education of the dental student (Clemens V. Rault, Georgetown University School of Dentistry). Panel discussions will follow on the criteria for admission to dental school and the criteria for admission to medical school.

American Physiological Society. Two-session symposium, cosponsored by the American Astronautical Society: "Man and His Environment in Space"; 30 and 31 Dec.; arranged by Fred A. Hitchcock, Ohio State University, and Paul A. Campbell, School of Aviation Medicine, Randolph Air Force Base, Texas.

Part I: "General Considerations"; Paul A. Campbell, presiding. Papers on the man-machine system in space vehicles (George W. Hoover, Office of Naval Research), protection of man against transient exposure to high heat loads (Paul Webb, Aeromedical Laboratory, Wright Field), physiological telemetry (Miles McLennan, Wright Air Development Center), biodynamics of launch and reentry profiles (Edward Hiatt, Wright Air Development Center), psychological research on the environment of outer space (Frederick Rohles, Jr., Wright Air Development Center), physiological factors in space environment (Norman Barr, Medical Corps, U.S. Navy).

Part II, cosponsored in addition by the Society for Industrial Microbiology: "The Closed Ecological System"; Fred A. Hitchcock, presiding. Papers on a comparison of artificial environments used in sealed cabins during flights into the stratosphere (Malcolm D. Ross, Office of Naval Research), survival of terrestrial microorganisms under simulated Martian environmental conditions (John D. Fulton, School of Aviation Medicine, Randolph Air Force Base), the relation of oxygen consumption to oxygen tension (Dietrick E. Beischer, U.S. Navy), closed ecological subsystems—some practical application problems in manned space flight (Bruce W. Pine, U.S. Air Force Ballistic Missile Division), exploratory research on the theoretical consideration of waste-water cycles in a

closed ecological system (William T. Ingram, New York University), atmospheric contaminants and their control (Gerald J. Duffner, Medical Corps, U.S. Navy).

American Psychiatric Association. Four-session symposium: "Hallucinations"; arranged by Louis Jolyon West, University of Oklahoma School of Medicine; 27 and 28 Dec.

Part I, Milton Greenblatt, Massachusetts Mental Health Center, presiding. Introduction by Louis Jolyon West. Papers on neurophysiological mechanisms underlying hallucinations (Edward V. Evarts, National Institute of Mental Health), hallucinations and the reticular formation (Arnold B. Scheibel, University of California at Los Angeles, Medical School), pharmacodynamics of hallucinations (Amedeo S. Marrazzi, Veterans Administration Research Laboratories in Neuropsychiatry), a comparison of drug-induced hallucinations with those seen in spontaneously occurring psychoses (Sidney Malitz, New York State Psychiatric Institute), a comparison of the visual hallucinations in schizophrenia with those induced by mescaline (Irwin Feinberg, National Institute of Mental Health), hallucinations in neurological syndromes (Maitland Baldwin, National Institute of Mental Health).

Part II: Panel on "Hallucinations in Sensory Deprivation"; Jay T. Shurley, University of Oklahoma School of Medicine, moderating. Panel members are Eugene L. Bliss, University of Utah Medical School; Philip Solomon, Harvard School of Medicine; Jack A. Vernon, Princeton University; Woodburn Heron, McGill University; Sanford Freedman, Massachusetts Mental Health Center; Albert J. Silverman, Duke University School of Medicine; Harold L. Williams, Walter Reed Army Institute of Research; and Thomas I. Myers, Human Relations Research Organization.

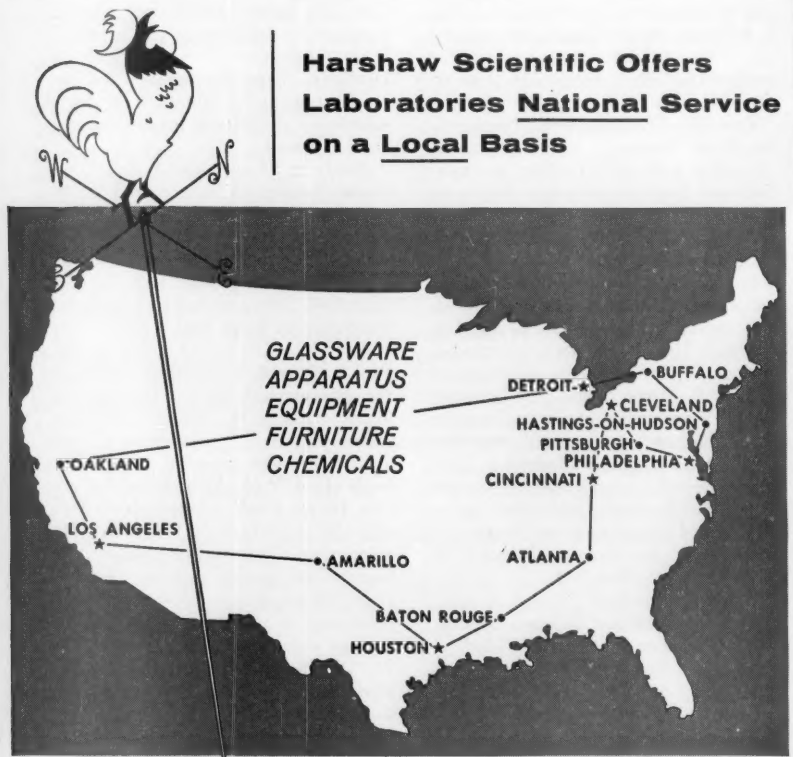
Part III, Lawrence C. Kolb, Columbia University College of Physicians and Surgeons, presiding. Papers on hallucinations in schizophrenia and their relation to psychic structures (Arnold H. Modell, Massachusetts Mental Health Center), hallucinations: comments reflecting clinical observations (Otto A. Will, Jr., Chestnut Lodge, Rockville, Md.), mechanisms related to the hallucinogenic effects of Tarexein (Robert G. Heath, Tulane University Medical School). hallucinations in children (Leon Eisenberg, Johns Hopkins University School of Medicine), hypnotically induced hallucinations (Martin Orne, Massachusetts Mental Health Center), the phenomenology of hallucinations (Erwin W. Straus, Veterans Administration Hospital, Lexington, Kentucky).

Part IV, Robert G. Heath, presiding. Papers on tactile hallucinations as a communication (James Clarke Moloney, Birmingham, Michigan), the hallucinations of the mystic (Edward A. Weinstein, Department of Mental Health, St. Thomas, Virgin Islands), phantom sensations, hallucinations, and the body image (Lawrence C. Kolb), the body image in relation to hallucinations (Seymour Fisher, Baylor University School of Medicine), psychophysics, reality, and hallucinations (Sandford Goldstone, Baylor University School of Medicine), a general theory of hallucinations (Louis Jolyon West).

Dentistry

Section Nd. Three-session symposium, cosponsored by the American College of Dentists, the American Dental Association, and the International Association for Dental Research, North American Division, and by AAAS Sections F (Zoological Sciences) and N (Medical Sciences): "Calcification in Biological Systems"; 29 Dec.; arranged by Reidar F. Sognnaes, Harvard School of Dental Medicine.

Part I, Roy O. Greep, Harvard School of Dental Medicine, moderating. Speakers will be Gerrit Bevelander, New York



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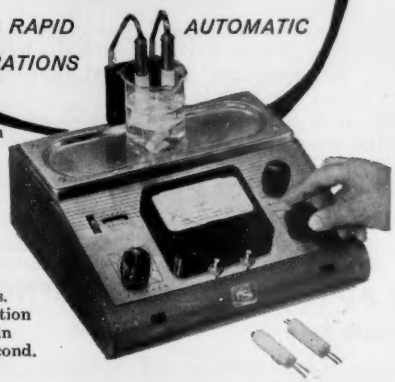

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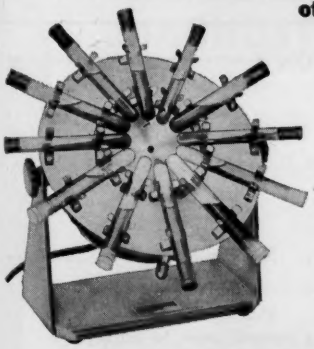

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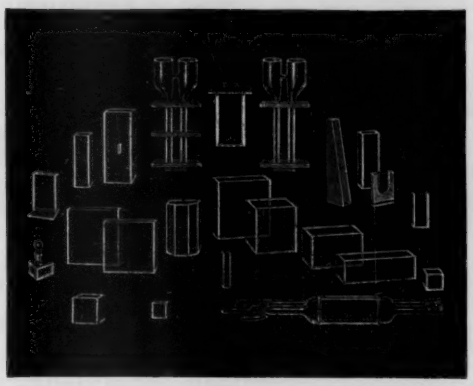

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Part II, Reidar F. Sognnaes, moderating. Papers will be read by Marvin S. Burstone, National Institute of Dental Research; Robert M. Frank, Institut Dentaire, Strasbourg; Reidar F. Sognnaes; Clive C. Solomons and William F. Neuman, University of Rochester School of Medicine and Dentistry; James T. Irving, South African Council for Scientific and Industrial Research and the University of Witwatersrand; Robert A. Robinson, Johns Hopkins University; Reuben Eisenstein, Richard E. Trueheart, and George M. Hass, University of Illinois College of Medicine; and S. Wah Leung, University of Pittsburgh School of Dentistry.

Part III, Franklin C. McLean, University of Chicago, moderating. Papers will be read by Melvin L. Moss, Columbia University College of Physicians and Surgeons; Paul Goldhaber, Harvard School of Dental Medicine; Karl A. Piez; Jerome Gross, Massachusetts General Hospital; Aaron S. Posner, National Bureau of Standards; and Melvin J. Glimcher, Massachusetts Institute of Technology.

Pharmacy

Section Np. Vice-presidential address, "The AAAS and Pharmacy," by George F. Archambault, U.S. Public Health Service; 28 Dec.; coordinated by John R. Kenny, Jr., E. R. Squibb and Sons.

Eight sessions, cosponsored by the American Pharmaceutical Association, Scientific Section; the American Association of Colleges of Pharmacy; the American Society of Hospital Pharmacists; the American College of Apothecaries; and the National Association of Boards of Pharmacy.

Contributed papers; arranged by John E. Christian, Purdue University; 27 Dec.; Justin L. Powers, American Pharmaceutical Association, presiding.

Contributed papers on hospital pharmacy; arranged by George F. Archambault, U.S. Public Health Service, and Joseph A. Oddis, American Hospital Association; 28 Dec.; Joseph A. Oddis, presiding.

Contributed papers on hospital pharmacy; arranged by George F. Archambault; Joseph A. Oddis; and William F. Apple, American Pharmaceutical Association; 28 Dec.; George F. Archambault, presiding.

Symposium: "Hospital Pharmacist of the Future"; 28 Dec.; William F. Apple, presiding. Papers will be read by Charles U. Letourneau, Hospital Management Magazine; Charles W. Bliven, George Washington University; Kenneth Nelson, U.S. Public Health Service; and Joseph A. Oddis.

Contributed papers; arranged by John E. Christian; 29 Dec.; Chauncey I. Cooper, Howard University College of Pharmacy, presiding.

Symposium: "Advances in Conquering Cancer"; arranged by George F. Archambault; Joseph A. Oddis; Stuart Sessoms, National Cancer Institute; and Milton Skolaut, National Institutes of Health; 29 Dec.; Stuart Sessoms, presiding. Papers will be read by Stuart Sessoms; T. Phillip Waalkes, National Cancer Institute; Milton Skolaut; and Roderick Murray, National Institutes of Health.

Tours of the National Institutes of Health and the American Institute of Pharmacy have been arranged for 29 Dec.

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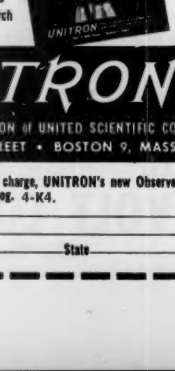

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Meetings

Forthcoming Events

December

18–20. American Physical Soc., Los Angeles, Calif. (K. K. Darrow, APS, Columbia Univ., New York 27.)

26–31. American Assoc. for the Advancement of Science, annual, Washington, D.C. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5, D.C.)

27–29. American Economic Assoc., Chicago, Ill. (J. W. Bell, AEA, Northwestern Univ., Evanston, Ill.)

27–29. Econometric Soc., Chicago, Ill. (R. Ruggles, Box 1264 Yale Station, Yale Univ., New Haven, Conn.)

27–30. American Folklore Soc., New York, N.Y. (MacE. Leach, AFS, Univ. of Pennsylvania, Philadelphia, Pa.)

28–30. Archaeological Inst. of America, Cincinnati, Ohio. (L. A. Campbell, AIA, Dept. of Classics, Brooklyn College, Brooklyn, N.Y.)

29–30. National Council of Teachers of Mathematics, New York, N.Y. (M. H. Ahrendt, NCTM, 1201 16 St., NW, Washington 6.)

28–30. Western Soc. of Naturalists, Seattle, Wash. (J. P. Harville, San Jose State College, San Jose 14.)

January

7–9. Northeastern Weed Control Conf., 13th annual, New York, N.Y. (E. R. Marshall, Carbide & Carbon Chemical Co., New York, N.Y.)

12–14. Reliability and Quality Control, 5th natl. symp., Philadelphia, Pa. (W. T. Sumerlin, Philco Corp., 4700 Wissahickon Ave., Philadelphia 44.)

20–22. American Mathematical Soc., annual winter, Philadelphia, Pa. (E. G. Begle, Leet Oliver Hall, Yale Univ., New Haven, Conn.)

21–22. American Group Psychotherapy Assoc., 3rd annual institute, New York, N.Y. (C. Beukenkamp, Public Relations Chairman, 993 Park Ave., New York 28.)

22–23. Mathematical Assoc. of America, 42nd annual, Philadelphia, Pa. (H. M. Gehman, MAA, Univ. of Buffalo, Buffalo 14, N.Y.)

23–24. American Group Psychotherapy Assoc., 16th annual conf., New York, N.Y. (C. Beukenkamp, Public Relations Chairman, 993 Park Ave., New York 28.)

26–29. American Meterological Soc., New York, N.Y. (K. C. Spengler, AMS, 3 Joy St., Boston 8, Mass.)

26–29. American Soc. of Heating and Air Conditioning Engineers, 65th annual, Philadelphia, Pa. (W. M. Vidulich, ASHACE, 62 Worth St., New York 13.)

26–29. Institute of the Aeronautical Sciences, 27th annual, New York, N.Y. (IAS, 2 E. 64 St., New York 21.)

27–30. Society of Plastics Engineers, Inc., 15th annual tech. conf., New York, N.Y. (L. A. Bernhard, SPE, 65 Prospect St., Stamford, Conn.)

28–29. Nuclear Fuel Elements, 1st intern. symp., New York, N.Y. (H. H. Hausner, 1st intern. Symp. on Nuclear Fuel Elements, 730 Fifth Ave., New York 19.)

28–31. American Physical Soc., annual, New York, N.Y. (E. R. Fitzgerald, Dept. of Physics, Pennsylvania State Univ., University Park.)

29–31. Western Soc. for Clinical Research, 12th annual, Carmel-by-the-Sea, Calif. (W. N. Valentine, Office of the Secretary, Univ. of California Medical Center, Department of Medicine, Los Angeles 24.)

February

1–6. American Inst. of Electrical Engineers, winter general, New York, N.Y. (N. S. Hibshman, 33 W. 39 St., New York 18.)

9–11. Nature of Coal, symp., Bihar, India. (Director, Central Fuel Research Inst., P. O. Fuel Research Inst., Dhanbad District, Bihar.)

12–13. Solid State Circuits Conf., Philadelphia, Pa. (A. B. Stern, General Electric Co., Bldg. 3, Syracuse, N.Y.)

14. Short Range Navigation Aids., Montreal, Canada. (Intern. Civil Aviation Organization, Maison de l'aviation internationale, Montreal.)

15–19. American Inst. of Mining, Metallurgical, and Petroleum Engineers, annual, San Francisco, Calif. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

16–19. Problems in Field Studies in Mental Disorders, intern. work conf., New York, N.Y. (J. Zubin, American Psychopathological Assoc., 722 W. 168 St., New York 32.)

20–21. Epidemiology in Mental Disorders, annual meeting of the American Psychopathological Assoc., New York, N.Y. (J. Zubin, APA, 722 W. 168 St., New York 32.)

26–28. Genetics and Cancer, 13th annual symp. on fundamental cancer research, Houston, Tex. (Editorial Office, Univ. of Texas, M. D. Anderson Hospital and Tumor Inst. Texas Medical Center, Houston 25.)

27–1. National Wildlife Federation, 23rd annual convention, New York, N.Y. (NWF, 232 Carroll St., NW, Washington 12.)

March

1–5. Gas Turbine Power Conf., Cincinnati, Ohio. (O. B. Schier, ASME, 29 W. 39 St., New York, N.Y.)

8–12. Aviation Conf., Los Angeles, Calif. (O. B. Schier, ASME, 29 W. 39 St., New York, N.Y.)

16–20. American Inst. of Chemical Engineers, Atlantic City, N.J. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36.)

16–20. National Assoc. of Corrosion Engineers, 15th annual conf., Chicago, Ill. (NACE, Southern Standard Bldg., Houston, Tex.)

18–25. International Social Science Council, 4th general assembly (by invitation), Paris, France. (C. Levi-Strauss, Secretary-General, International Social Science Council 19, avenue Kleber, Paris.)

(See issue of 21 November for comprehensive list)

Equipment

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Science *does not assume responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 1358.*

■ NUMERICALLY CONTROLLED POSITIONING SYSTEMS for machine tools are available in push-button keyboard types and in fully automatic versions controlled by standard 1-in. punched paper tape. Positional distances in translation are measured and set in inches and decimals. Typical performance provides a range of 99.999 in. in steps of 0.001 in. with accuracy and repeatability within ±0.00025 in. Backlash is automatically taken up. (Wang Laboratories Inc., Dept. 480)

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■ MASS FLOWMETERS are calibrated directly in milligrams of air per minute. Flow measurement is accomplished by incorporating a heated thermopile element in a flow tube. The thermopile circuit is self-compensating for both ambient temperature and rate of change of temperature. Various ranges are available. Typical are model MF-1, with range from 0 to 10,000 mg/min, and model SM-1, with range from 0 to 500 mg/min. (Hastings-Raydist, Inc., Dept. 486)

■ RELAY TEST SET automatically tests ten relays simultaneously for normal operate time, saturate release time, or release time after predetermined heating. Time intervals are read to 0.1 sec on digital timing clocks. Energizing voltage is continuously adjustable between 2.5 and 230 v. (G. V. Controls Inc., Dept. 490)

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■ SCINTILLATION ANALYZER is designed for analytical measurement of isotopes emitting either gamma or hard beta rays or a mixture of both in solid or liquid samples. Separation of gamma emission is effected by means of a pulse-height selector that determines the spectrum operating point. The instrument permits scintillation well counting of betas of higher than 1-Mev energy without source preparation. (Baird-Atomic Inc., Dept. 494)

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POSITIONS OPEN

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Biologist, teach, small undergraduate liberal arts college for women, East, September. Box 243, SCIENCE. X

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17
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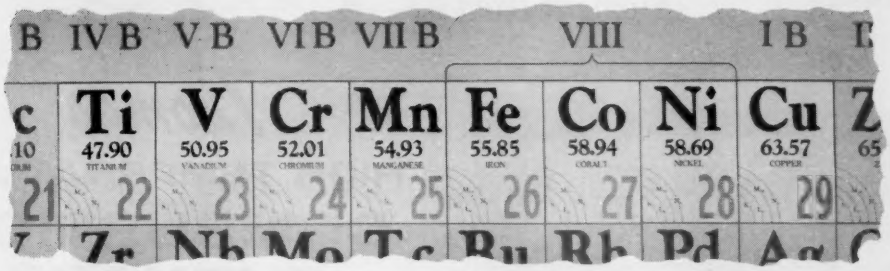
B IV B V B VI B VII B VIII I B
Ti 47.90 TITANIUM 22
V 50.95 VANADIUM 23
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Where a trace of a transition element ion constitutes either a harmful impurity or a key to a chemical, physical or biological phenomenon, quantitative determination by E-P-R spectroscopy has a number of advantages. The test is fast and non-destructive. A typical sample size is 0.1 cc and the method is effective on concentrations as low as 10^{-6} molar. On a routine basis a quantitative E-P-R test can be made in a few minutes. The same results by chemical analysis might require hours or days of painstaking effort.

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Number 17 of a series **FORBIDDEN TRANSITIONS IN A VANADYL CHELATE**[1]

INTERPRETATION: Hyperfine structure of VO^{++} in solution has been studied by Poke and Sands[2]. The transitions which they observed correspond to $\Delta M_S = \pm 1$ and $\Delta M_I = 0$ where M_S and M_I are the eigenvalues of the operators S_Z and I_Z. Observations of transitions of this ion which correspond to $\Delta M_S = \pm 1$ and $\Delta M_I = \mp 1$ can be made when the constant magnetic field H_Z and the radio frequency field $2H_1$ are parallel to each other. The transitions correspond to a mutual spin flip of the electron and nucleus and were observed in a sample of vanadylacetylacetone dissolved in benzene.

The relative intensities of these lines have been calculated from perturbation theory and compared to the line intensities of the normal transitions. Since we are well below saturation this ratio should be just the ratio of squares of the matrix elements $g^\beta(2H_1)S_Z$ and $g^\beta(2H_1)S_X$. Using wave-functions obtained from first order perturbation theory one finds the relative intensities of the $\Delta M_S = \pm 1$, $\Delta M_I = \mp 1$ lines to the intensities of any $\Delta M_S = \pm 1$, $\Delta M_I = 0$ lines in the ratio of $7\Sigma^2$, $12\Sigma^2$, $15\Sigma^2$, $16\Sigma^2$, $15\Sigma^2$, $12\Sigma^2$, $7\Sigma^2$ where $\Sigma = \frac{A}{g^\beta H_Z} \cong 0.03$.

Excellent agreement with these theoretical ratios is obtained when the experimental intensities of the two transitions are compared. Fig. 1 is a spectrum of the normal transitions and Fig. 2 of the forbidden transitions at an increased gain setting of 100. The normal transitions are also visible in this trace as the 1, 3, 5, 7, 9, 11, 13 and 15 lines.

(1) *In press J. Chem. Phys.*
(2) *Phys. Rev. 98 266A (1955)*

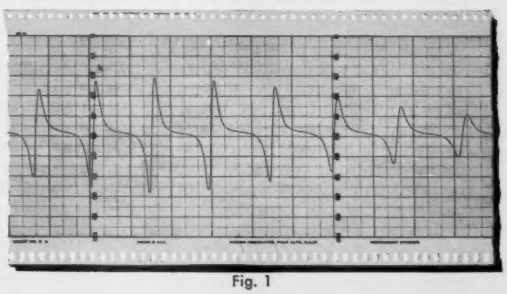

Fig. 1

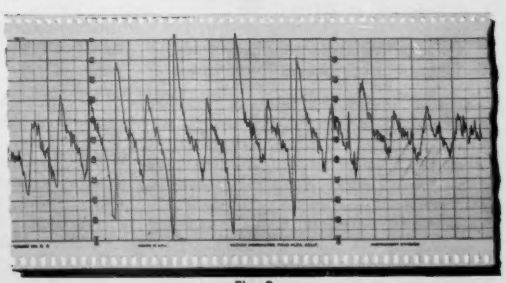

Fig. 2

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A built-in Platinum-Platinum 13% Rhodium thermocouple is supplied with the Furnace. An external removable thermocouple of identical characteristics is offered for direct determination of temperatures existing within the combustion tube. A switch permits reading of temperatures of either thermocouple on the pyrometer.

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